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Proceedings of the Symposium on Work Zone Traffic Control

Office of Research and Development
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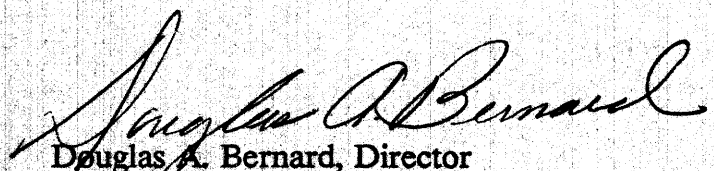
FOREWORD

This document contains the proceedings for the Work Zone Traffic Control Symposium held in Orlando, Florida on January 18-19, 1991. The purpose of the symposium was to disseminate state-of-the-art procedures and practices for making work zone traffic control work for motorists, pedestrians, and workers at all levels on freeways, city and suburban streets, and rural roads. This document will be of interest to those responsible for the design, implementation, or maintenance of work zone traffic control.

Copies of the document are being distributed to the Federal Highway Administration Regional and Division offices and to each State highway agency. Additional copies of the document are available from the National Technical Information Service, 5280 Port Royal Road, Springfield, Virginia 22161.



Douglas A. Bernard, Director
Office of Technology Application

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16. Abstract

Fatalities from motor vehicle accidents in work zones continue to increase. To improve safety and efficiency of day-to-day maintenance and operations of work zones, the Federal Highway Administration sponsored a two-day symposium, "Work Zone Traffic Control Symposium--Making It Work," in Orlando, Florida on January 18-19, 1991. Gathered at the symposium were representatives from Federal agencies, States, cities, counties, industry, and foreign countries.

The purpose of the symposium was to disseminate information on state-of-the-art procedures, practices, and equipment for making work zone traffic control work for motorists, pedestrians, and workers on freeways, city and suburban streets, and rural roads. A wide spectrum of topics was covered, including the new Part VI of the Manual on Uniform Traffic Control Devices, contracting procedures, training, speed control techniques and devices, tort liability, planning and scheduling lane closures, and public information campaigns. The symposium included break-out sessions where the attendees became program participants by sharing their experiences and procedures for improved work zone traffic control.

The symposium culminated with a tour of the annual trade exhibit of the American Traffic Safety Services Association that was held at a nearby hotel.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

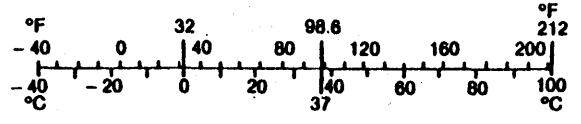
Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9	Celcius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
TEMPERATURE (exact)				
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F



* SI is the symbol for the International System of Measurement

(Revised April 1989)

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EXECUTIVE SUMMARY

This proceedings document describes the "Work Zone Traffic Control Symposium--Making It Work," which was sponsored by the Federal Highway Administration in Orlando, Florida on Friday, January 18 and Saturday, January 19, 1991. Representatives from Federal agencies, States, cities, counties, industry, and foreign countries attended the symposium, whose objective was to improve the safety and efficiency of day-to-day maintenance and operation of work zones.

The first day's morning session opened with welcoming remarks from Bill Deyo, Florida Department of Transportation. E. Dean Carlson, Executive Director, Federal Highway Administration, charged individuals in the group to commit themselves to halting and reversing the trend of increasing number of fatalities in work zones. He pointed out that as the Nation works at maintaining and rehabilitating existing highways, the number of work zones will grow significantly from 30,000 annually now. He implored participants to dedicate themselves to improving safety and efficiency of the day-to-day maintenance and operations of work zone traffic control by understanding problems and using available resources wisely.

Plenary presentations on Work Zone Safety--Is It Working, New Part VI of the Manual of Uniform Traffic Control Devices (MUTCD), and Causes and Prevention of Tort Liability in Work Zones Traffic Control followed. The morning ended with a panel discussion on Contracting Procedures for Work Zone Traffic Control.

The afternoon program included plenary sessions on the Use of Police for Work Zone Traffic Control, New Concepts in Work Zone Traffic Control, Warrants and Proper Deployment of Flashing Arrow Panels, Current Practices in the Use of Steady-Burn Warning Lights, Guidelines for the Use of Truck-Mounted Attenuators, and Safe Deployment of Traffic Control Devices.

Saturday morning's program consisted of three concurrent break-out sessions on "Making It Work" with presentations and discussions of work zone traffic control on freeways, city and suburban streets, and rural roads. In the afternoon, plenary sessions addressed Public Awareness of Work Zone Activity, Inspection of Work Zone Traffic Control Hardware--A Systematic Approach, Work Site Traffic Control Training and Certification, and Management of WZTC--Making It Work!

The program continued with a plenary panel discussion of Work Zone Traffic Control--Making It Better. Philip Russell, Federal Highway Administration, gave closing remarks and adjourned the symposium.

On Sunday, January 20 the symposium participants attended the opening session of the American Traffic Safety Services Association's (ATSSA) 21st Annual Convention and Traffic Expo that was held at a nearby hotel.

WORK ZONE TRAFFIC CONTROL–MAKING IT WORK

Following opening remarks by Bill Deyo, Florida Department of Transportation, E. Dean Carlson, stated the objective of the symposium, "to improve safety and efficiency of day-to-day maintenance and operation of work zone traffic control. He noted that many work zone traffic control plans are not maintained or operated as safely and efficiently as possible and cited increased numbers of fatalities in work zones occurring when fatalities relating to motor vehicle accidents on the Nation's highways decreased. Work zone traffic control plans have improved because of advancements in devices, specifications, and training, he said. However, inadequate day-to-day housekeeping and supervision, lack of timely changes to plans, and failure to replace worn out devices limits the benefits of these improvements and creates safety hazards for workers and motorists in work zones.

Philip O. Russell, Federal Highway Administration, reported on revisions being made to Part VI of the MUTCD, which will define more clearly and establish standards for traffic control devices and their application. He stated that a notice of proposed rulemaking is expected to be published in the Federal Register by September 1991, with final rulemaking expected in November 1992.

Russell M. Lewis discussed Tort Liability--Causes and Preventions. He specified good engineering and work practices that are useful in enhancing an organization's defensive posture and mitigating liability. These included the following: accident avoidance, injury reduction, ways to identify potential accidents, inspection and maintenance practices, following accepted standard of care, collecting perishable field data, comprehensive training, and good documentation.

PANEL DISCUSSION: CONTRACTING PROCEDURES FOR WORK ZONES

Larry C. Smith, FHWA's Federal Lands Highway Office; Thomas Hicks, Maryland State Highway Administration; Richard A. Dun, Hubbard Construction Co.; and I. Sharon Fischer, Priceless Sales and Services, Inc., examined contracting procedures for traffic control in work zones that promote safe, successful completion of jobs. Contracting was addressed from the different perspectives of Federal and State agencies, contractors, and subcontractors. Issues included: division of responsibilities and liabilities, training, methods of payment, planning for unforeseen circumstances, use of law enforcement, and teamwork.

The consensus of the panel was that contracts should delineate the responsibilities and liabilities of those involved in work zones--the agency, the contractor, the engineer, and the subcontractors. Contracts should be clear and specific in regard to work zone traffic control devices. Panelists agreed that contracts should designate a trained traffic supervisor who is responsible for day-to-day operations. They emphasized the importance of using trained, experienced personnel and of frequent daytime and nighttime inspection. Unit pricing was the preferred method of payment.

GENERAL SESSION: PRACTICAL APPLICATIONS IN WORK ZONE TRAFFIC CONTROL

Captain Terry Conner, Arizona Department of Public Safety, focused on the need for cooperation between construction contractors, engineers, and law enforcement officials in highway work zones. He stated that law enforcement personnel can recognize hazards that may lead to a crash within a work zone, and they know how to deal with inattentive or disrespectful driver behavior.

Information on new devices, methods, and concepts for work zone traffic control were presented by Robert M. Garrett, Executive Director of ATSSA, Inc.. Garrett highlighted devices that protect workers and pedestrians and those which are "forgiving" when struck by errant vehicles. Many of the innovative devices were on display at the ATSSA 21st Annual Convention and Traffic Expo, "Making Safety Work," that was held January 20-22 nearby in Orlando.

Joseph J. Lasek, Federal Highway Administration, reported on warrants and the proper deployment of flashing arrow panels. Lasek cited existing problems with placement, application, and sight obstacles. He pointed out that the application of arrow panels is included in the Part VI of the MUTCD that is undergoing revision; therefore, he advised participants to watch for changes. He discussed current MUTCD provisions, applications, and solar-powered arrow panels.

Current practices in the use of steady-burn warning lights in the U.S. was introduced by Gerhart F. King, KLD Associates, Inc. King reported on the progress of a study by ATSSA to define the proper role of Type C steady-burn warning lights in work zone traffic control, including maintenance requirements. King focused on the results of a survey designed to define current usage patterns of steady-burn warning lights and problems associated with the use of these devices. The presentation analyzed the replies received from U.S. State highway agencies and from U.S. companies engaged in the rental, installation, operation, and maintenance of warning lights and other highway work zone traffic control devices.

The use of truck-mounted attenuators (TMA's) was addressed by Jack B. Humphreys, University of Tennessee. Following a nationwide study of the use of truck-mounted attenuators, recommended guidelines for the use of shadow/barrier vehicles and TMA's were developed. Because a large volume of data was not collected, Humphreys notes that the guidelines are best used as a policy formulation and budgeting tool.

Jerry Hietpas, Action Safety Supply Co., presented a plan for safe deployment of work zone traffic control systems. He provided step-by-step strategies from planning to removal of work zone traffic control devices at the completion of the job.

CONCURRENT BREAKOUT SESSIONS

Group 1--Traffic Control for Work Zones on Freeways

Raymond A. Krammes, Texas A & M University, discussed planning and scheduling freeway lane closures. He focused on a computer model QUEWZ3-PC, which stands for Queue and User Cost Evaluation of Work Zones. It can estimate the queue length and can identify time schedules when lanes may be closed without producing unacceptable delays. Krammes presented examples of applications of QUEWZ3-PC that illustrate how traffic impacts may be accounted for when planning and scheduling freeway work zone lane closures.

Real-time traffic control and changeable message signs were covered by Thomas Hicks, Maryland State Highway Administration. His presentation included: traffic control philosophy, device standards, customer service, specifications, traffic control plan, credibility, information gathering, monitoring, data collection, information verification, dispensing information on road use, and Traveller's Advisory Radio (TAR).

James Migletz, Graham-Migletz Enterprises, Inc. talked about work zone speed control procedures. He noted that reduced work zone speed limits decrease average speed, but also increase speed variance, which increases accident rates. He observed that drivers do not believe that speed should be reduced when there is no work or work is off of the traveled way. He discussed the most effective speed control treatments--flagging and speed enforcement--and talked about changeable message signs and narrow lanes. He recommended reducing the speed limit as little as possible, consistent with safe traffic operations, but not more than 10 mi/h on urban freeways and not more than 15 mi/h on rural roads.

The final panel speaker, William Walsh, Florida Department of Transportation, described the $400 million Interstate 95 expansion project underway in Florida. He highlighted Florida's well developed maintenance of traffic plan and rigorous public information program, whose objective is to mitigate the impact to the public during the reconstruction.

Group 2--Traffic Control for Work Zones on City and Suburban Streets

Archie Burnham, Jr., consultant, gave an overview of work zone traffic control for urban/suburban streets, including the scope of the problem, significant programs that address the problem, standards and assistance, and several areas of misunderstanding. While problems exist, Burnham cited training courses by ATSSA, the Georgia Safety Council and several cities and States as evidence of growing interest in work zone safety. He noted that a Transportation Research Board publication, scheduled for release in early 1991, should be of additional assistance.

Protecting Pedestrians in Work Zones: Role for the MUTCD was the topic of Errol C. Noel, Howard University. Noel stated that although much has been accomplished regarding work zone safety, the safe accommodation of pedestrians in work zones is frequently neglected and is not sufficiently addressed in the MUTCD or the Traffic Control Devices Handbook. Based on field observations, review of documented policies, and discussions with traffic safety officials in a number of cities, Noel developed a selection of practices for providing pedestrian safety in work zones, including building codes, building permits, coordinated management of traffic, traffic control plans, general specifications, information signs, protection devices, and delineation.

Rick L. Maddux, Cedar Falls Utilities, spoke on moving from a casual "no-cones" approach to a commitment to no accidents in utility work areas. He provided ideas for utility companies on how to improve traffic control in utility work zones. He described his company's new employee orientation; flagger handbook; flagger video; equipment, including signs and cones; emergency assistance; annual training; and subcontractors.

A model traffic control ordinance was presented by Larry W. Settle, City of Overland Park. He discussed the basis for creation of a traffic control ordinance and procedural information, including preparation, orientation, training, and enforcement.

Group 3–Traffic Control for Work Zones for Rural Roads

Lane closure techniques used in Minnesota for two-lane roads were described by Jon V. Jackels, Minnesota Department of Transportation. Jackels discussed the importance of following work zone traffic control procedures, including design for short- and long-term projects; daily planning; training; using proper devices; and providing proper operation, including installation, maintenance, and inspection. He also discussed techniques to improve safety and efficiency, as well as new technologies in short-term work zone traffic control, such as reflectorized roll-up signs, portable traffic signals, and portable rumble strips. He also described a STOP/SLOW paddle with supplementary flashing lights and the need for development of robotics to control vehicles, equipment, and traffic control devices.

Larry C. Smith, Federal Lands Highway Office, spoke on applying the MUTCD to rural roads, which have a range of conditions, from extremely low to not-so-low volume, from major grading/reconstruction to simple overlays, as well as problems due to inexperienced contractors and budgetary, seasonal, and weather concerns. He discussed assumptions used in the MUTCD and latitude permitted by the MUTCD, and recommended speed reduction zones, long-term travelled way/construction zone delineation, and special standards for low-volume roads.

Robert L. Morrison, Hancock County, Ohio engineer, talked about rural low-volume road work zone traffic protection. He described, in real-world terms, how the guidelines are implemented in a low-volume road situation in a rural county.

Training through the Regional Transportation Assistance Program (RTAP) was covered by Henry Sandhusen, Federal Highway Administration. He reported on RTAP centers, where they are, and what they provide in training. He distributed a hand-out of the current addresses and contact persons of RTAP Centers. He also described the video-assisted training program and other materials available through the RTAP Centers..

GENERAL SESSION--MAKING IT WORK THROUGH PUBLIC INFORMATION, INSPECTION, AND MANAGEMENT

Lynda J. South, Virginia Department of Transportation, spoke on public awareness campaigns in 15 States, including California, Michigan, Virginia, Pennsylvania, and New Jersey. She pointed out that five years ago only a few States had campaigns to inform the public about work zone safety, but today approximately 20 States conduct campaigns, many in partnership with organizations that have an interest in worker and motorist safety. South distributed a work zone safety newsletter published by the American Association of State Highway and Transportation's (AASHTO) Subcommittee on Public Affairs. She credited that subcommittee with being a catalyst for the development of some excellent State work zone public awareness campaigns and in promoting public awareness nationwide.

Donald L. Woods, Texas A & M University, talked about a systematic approach to inspection of work zone traffic control hardware. Woods described the check-list system developed for the Texas State Department of Highways and Public Transportation and suggested how to adapt it for use by other States or local governmental units. The check list provides inspectors with something to assist them in recalling the wide variety of technical details needed.

Training and certification for all personnel in work zone traffic control was the topic addressed by Victor H. Liebe, American Traffic Safety Services Association. Training, Liebe said, is crucial to an effective work zone traffic control plan. Training and certification results in uniformity of interpretation and application of the standards and guidelines in the design and operation of work zone traffic control. Liebe described ATSSA's 3-day, 20-hour "Training Course for Work Site Traffic Supervisors."

Johan J. Bemelen, Colorado Department of Highways, talked about efforts in the Denver metropolitan area to improve traffic control through work zones, including a district-wide work zone traffic control review program, the I-25 traffic control support project, and a public relations project.

PANEL DISCUSSION--MANAGEMENT OF WORK ZONE TRAFFIC CONTROL--MAKING IT BETTER!

Harry B. Skinner, Federal Highway Administration; Bill Deyo, Florida Department of Transportation; Robert L. Morrison, Hancock County, Ohio; and Victor H. Liebe, American Traffic Safety Services Association made up the final panel that addressed management of work zone traffic control. Skinner pointed out the significance of uniform standards, uniform applications of standards, inspections, and training. He stated that the Federal Highway Administration is dedicated to enhancing safety in the highway work zone for the construction worker and the motorist. Other topics covered by panelists included the importance of training and up-to-date uniform standards, communication in management, and teamwork in management.

SUMMARY

Harry B. Skinner urged participants to commit themselves to reducing the number of injuries and fatalities in work zones. Because the number of work zones is increasing as the Nation maintains and rehabilitates its roads and highways, safety in work zones will play a vital role in ensuring that the transportation system supports public safety--a national transportation policy, as stated by Secretary of Transportation Samuel K. Skinner.

Problems that contribute to unsafe work zones include: insufficient attention to day-to-day maintenance of work zone traffic control; lack of training of managers and workers, especially at the small municipality and local utility level; misunderstanding by the public regarding snow plowing operations; and insufficient standards for accommodation of pedestrians in work zones. One problem area cited by many participants was failure to remove or cover work zone signs when work is not being performed, which causes motorists to ignore warning signs, even when work is underway. This problem was evident outside the hotel where the symposium took place--during the two days of the conference, work zone signs were in place, even though no work was done during the entire period!

Key points of the symposium included the importance of well-trained personnel at all levels; well-trained inspectors; certification--and recertification--through ATSSA and other groups; frequent daytime and nighttime inspection of work zones by qualified technical, as well as nontechnical, persons; uniform application of the MUTCD; the proper use of up-to-date equipment; speed control; effective public relations to get the message out to the public; and teamwork between agencies, engineers, contractors, subcontractors, and law enforcement personnel.

Participants were urged to be prudent in documentation of the traffic control plan. They were charged to be alert to changes, both in the MUTCD, and in technology available.

In most cases, unit pricing for traffic control devices was recommended. Highway agencies were advised to periodically review their unit price procedures to identify problems and revise their practices accordingly.

Independent oversight of project work zone traffic control operations was suggested. Successful programs cited include traffic control specialists who report to a district engineer or a district construction engineer. The specialists are responsible for systematically reviewing all projects in their area to identify deficiencies and recommend corrective action.

An active role by law enforcement was recommended, both in enforcement and in identifying problems that may exist in a work zone. The use of uniformed police is an effective way to control speed in work zones.

Day-to-day maintenance of work zone traffic control devices should be rigorous. Special attention should be paid to maintaining work zone traffic control plans, replacing worn out or damaged devices, and having the right device in the right place.

Skinner emphasized FHWA's dedication to the need for a set of uniform standards for traffic control through the work zone. He drew attention to the rewriting of Part VI of the MUTCD, currently underway, and announced plans to publish the revised Part VI as a stand-alone document for convenient use in the field. He noted that FHWA is convinced of a need for uniform application of standards throughout the life of a project. He also stressed the need for continuous inspection of operations to ensure that the work zone traffic control plan is being followed and is functioning properly.

WELCOMING REMARKS

Bill Deyo
Director, Office of Design
Florida Department of Transportation

On behalf of Secretary Ben Watts and the Florida Department of Transportation, I am pleased to welcome you to Orlando. This is certainly a timely meeting to discuss and share ideas on traffic control through the work zone, especially with the recent emphasis on safety countermeasures.

Other than for the famous "men working" sign when no work is occurring on jobs, most often we don't get glowing remarks or thank yous for keeping motorists and pedestrians moving safely through or around construction work zones. Rather, we get complaints when delays occur. In spite of the fact that the public recognizes the need for maintenance and construction activities, their willingness to be inconvenienced by these activities continues to be less and less. This we viewed as a challenge to provide somewhere near the same level of safety and mobility to the public during these various construction and maintenance operations on the highway systems. Toward the goal of achieving this safety level for motorists and pedestrians and cyclists, the Florida Department of Transportation, some years ago, developed an action plan for work zone traffic control (WZTC). This action plan included eight objectives toward this goal. Some of these are:

- Update Standards and Specifications
- Improve Traffic Control Plans
- Evaluate WZTC Training Needs
- Develop Quality Assessment Review Criteria

With all of these, we are progressing very well and have made great strides towards this goal. We have very good dynamic standards, a Quality Assurance review process, and certainly, improved traffic control plans.

One area receiving particular emphasis at this time involves our WZTC training. We have a very active training program being provided by a team of DOT engineers, as well as the American Traffic Safety Services Association (ATSSA). This training emphasizes our standard WZTC schemes -- "how to" for designers and construction engineers and contractors implementing these plans. Our DOT sponsored courses have trained more than 1,000 thus far. We have a Florida specific course -- Florida Standards and Specifications -- in addition to the ATSSA basics, such as flagging techniques.

In addition to this training, there is multi-discipline maintenance of traffic (MOT) committee which includes Construction, Design, Maintenance, Traffic Engineering, Value Engineering and FHWA. This cooperative effort for sharing ideas, communicating experiences, reviewing TCP and WZTC on a statewide basis is Making It Work for Florida. The communication efforts, including community involvement you'll hear about later in the symposium, include all news media to get the word out, -- places to avoid, travel times, etc., etc.

This is Making It Work!

Our action plan is in full swing. I hope this symposium is of some positive benefit. Again, WELCOME, we're ready to share our program with you.

WORK ZONE SAFETY -- IS IT WORKING?

E. Dean Carlson
Executive Director
Federal Highway Administration

I appreciate the opportunity to open this symposium. As some of you may be aware, my experience with the Federal Highway Administration (FHWA) extends over the last three decades with its beginnings as a project engineer with the Bureau of Public Roads. Throughout my career, I have had the same opportunities many of you now have to influence highway safety and operations. Personally, my greatest satisfaction came with direct involvement in the planning and implementation of projects, particularly the more complicated ones, which often required maintaining traffic through work zones.

During this symposium, you should be thinking about your role in "Making It Work." I would like you to consider the following four points and how they relate to you:

- The Problem — Many work zones are not maintained or operated as safely and effectively as possible.
- The Objective — Improve safety and efficiency of day-to-day maintenance and operations of work zones.
- The Situation — Understand what resources are available and how to apply them.
- The Commitment — Your role in "Making It Work."

I would now like to expand on each point beginning with the problem. Many work zones are not being maintained as safely or effectively as practical. I believe that 30 years ago, planning and implementing good work zone traffic control procedures was more difficult. I believe this because at that time work zone traffic control planning was only in its infancy. Traffic control devices were not as numerous or sophisticated as they are today, and few government employees or contractor's personnel were trained in the development and operation of construction work zones. This will probably date me, but I can remember a time when we used smudge-pots blackened-steel spheres filled with kerosene and illuminated with a wick. This was a common device for identifying a hazardous area along the roadway.

Work zone traffic control has come a long way since the smudge pot. However, even with all of the improved devices, specifications, traffic control plans, and training, traffic control in work zones continues to be unsatisfactory on many projects. The problems usually lie in the lack of day-to-day housekeeping, limited supervision, lack of timely changes, and failure to replace damaged and worn out devices.

I am being drawn back again into taking a personal interest in the intricacies of work zone traffic because of the growing number of fatalities associated with work zones in the last several years. Between 1985 and 1989, fatal accidents involving motor vehicles have increased from 679 to 782 or 15 percent. This is particularly disturbing when you consider that the total number of fatalities related to motor vehicle accidents on our Nation's highways decreased last year. During the last 5 years, fatal accidents on all highway systems have been rising at a rate of about 2.6 percent per year while work zone accidents rose 3.7 percent.

I believe we are not experiencing a levelling off of all fatal accidents in almost all other areas. I hope through your efforts, we can also halt and reverse the trend of increasing fatal accidents in work zones. Because more and more motorists, pedestrians, and workers are being exposed to the potential hazards or work zones, this rising accident trend is not expected to resolve itself. There are now over 30,000 work zones annually, and I anticipated this number will grow significantly as we continue to maintain and rehabilitate our existing highways. You need to ask yourself: "What can be done to improve work zone safety and efficiency?"

As I previously mentioned, our objective is to improve the safety and effectiveness of day-to-day operations and maintenance in work zones. The focus of this symposium is to identify techniques and procedures to "Make It Work." By this I mean identifying what form of unit prices, specifications, and highway-agency management techniques lead to improved day-to-day operations.

We are in a good situation to address this objective because we have the available resources and know-how to apply them. We currently have available the four basic building blocks necessary in developing safe, effective, and well maintained construction zones.

- The first building block includes an adequate inventory of appropriate traffic control devices. Many of the devices currently available to highway agencies, commercial enterprises, and contractors have been specifically developed to meet the driver's need for information and guidance while protecting the worker and motorist from potential impact danger. The appropriate use of a well maintained device is the hallmark of good work zone traffic control management. This symposium was developed to address the techniques and management activities necessary to keep traffic control devices effective. Our symposium coincides with the American Traffic Safety Services Association (ATSSA) 21st Annual Convention and Trade Show. I hope you will take the opportunity this Sunday to attend and view many new and improved devices, along with specialized equipment currently available for maintaining their effectiveness.

- A second building block essential to the development of good work zone traffic control consists of typical traffic layouts for common situations. The FHWA, through Part VI of the Manual of Uniform Traffic Control Devices (MUTCD)

and the Traffic Control Devices Handbook, provides typical work zone layouts for the most common situations. Many State and local agencies have developed standard drawings and details that supplement these layouts or satisfy situations or operations that are unique to their agency. I believe the use of well maintained standard layouts, along with the flexibility to make changes and improvements as appropriate, is essential for good day-to-day work zone operations.

- The use of a work zone traffic control plan is the third essential building block. It incorporates appropriate devices and layouts along with contracting procedures and specifications and provides for the easy identification and replacement of inadequate and nonstandard devices. The need for good planning, ability to recognize problems, and flexibility to make appropriate changes is critical to the day-to-day management of work zones and must be reflected in the work zone traffic control plan. A large portion of this symposium is structured around understanding the contractual arrangements necessary to support effective work zone traffic control plans. Although the resources are available, this is one area in which we have not been completely effective.

- The last building block includes the skills and abilities that are essential to the planning, implementation, and everyday maintenance of the work zone. A substantial number of training activities have been undertaken by highway agencies and ATSSA in the last several years. Several new courses, to be discussed at this symposium and at the ATSSA convention, have become available to help develop the skills and abilities of project engineers and technicians, maintenance crews, and construction workers involved in the day-to-day operation and maintenance of work zones. This is another area I regard as needing more attention. The individuals responsible for the maintenance of devices must be able to identify when a device is not acceptable and know what to do about it.

The last point I want to address is your personal commitment to "Making It Work." Responsibility for good day-to-day maintenance of work zones is shared by all of us:

• The Designers and Planners	Who produce the contracts, bid items, specifications, and develop traffic control plans.
• The Administrator and Managers	Who establish objectives, allocate resources, and develop programs.
• The Project Engineers Technicians	Who administer the contracts and inspect and review the work.
• The Contractors and Suppliers	Who do the work and provide the devices used.

- The Enforcement Officials — Who have authority for regulations of traffic in work zones.

Each of you should consider the following six elements necessary for good day-to-day operations. Consider which of these are within your areas of responsibility and how you can improve the situation:

- Develop responsibilities for managing, maintaining and monitoring work zone activities. Nighttime reviews are especially important and must be a part of the highway agency's and contractor's responsibilities.

- Identify the devices, layouts, and procedures necessary for good day-to-day work zone operations.

- Incorporate standards into the contract documents and maintenance procedures that define levels of acceptability for devices and layouts.

- Provide for payment in a form consistent with the desired use, maintenance, repair, or replacement of each type device.

- Provide for flexibility in management and operations of work zones. The project manager and contractor should have the ability to modify easily the traffic control plan to meet any new or unforeseen conditions.

- Inspect work zones and work zone devices on a routine basis both day and night.

As I mentioned previously, fatal accidents in work zones have been increasing since 1985. The Federal Highway Administrator recognized this trend several years ago and initiated several activities to reduce work zone accidents. The FHWA has also enthusiastically supported State and local efforts in developing and implementing work zone traffic control programs and procedures directed at reducing accidents in work zones. These efforts have been directed at improved safety for the motorist, pedestrian, worker, and enforcement personnel. Our objective was, and still is, to halt the growing number of work zone accidents and reverse this trend over the long term by improving work zone safety.

As many of you are aware, the administration's proposed legislation for the next highway authorization provides for Federal-aid projects to be focused on a system of national significance. This proposed system would probably include the Interstate, most of the Primary system, and some of the Secondary and Urban highways. I mention this only because I want you to understand that regardless of how the system is defined, the FHWA will remain committed to improving highway safety on all public roads. Our commitment to public safety, particularly to safety within the work zone, will continue to receive Federal support and emphasis.

NEW PART VI OF THE MUTCD

Philip O. Russell
Chief, Traffic Control Device Applications Branch
Federal Highway Administration

Part VI of the Manual on Uniform Traffic Control Devices (MUTCD) contains the standards and guidelines for traffic control in construction and maintenance work zones. This part of the document is being revised to define more clearly and establish standards for traffic control devices and their application. The Federal Highway Administration (FHWA), through a contract, developed a revised version of Part VI. This draft is being reviewed, and recommendations are being developed by the National Committee and others for submission to the FHWA.

One item that we are stressing is the importance of understanding the different areas of a work zone and what types of traffic control devices are appropriate to each area. Figure 1 shows the different areas of a typical work zone.

Revisions to Part VI are directed to improved typical layouts for traffic control devices. Additional examples have been developed to depict recommended traffic control on urban streets, utility work sites, detours, and pedestrian facilities. Figures 2, 3, and 4 depict examples of typical layouts for work zones. It is intended that they show more detailed and specific treatments than previously included in the MUTCD's. Particular attention is directed to device placement and layouts of typical work situations. Also, requirements for pavement markings and delineation are being clarified.

The current provisions are directed to the application of pavement markings at the end of each day. Markings to full standards should be installed in about two weeks. We continue to receive comments and recommendations that 4 ft requirements for short-term markings be changed to 2 ft. The FHWA has research underway that is looking at this standard. Any changes in pavement marking requirements would be developed only if clearly supported by research. The FHWA goal is to provide pavement markings at all times to the extent practical.

The following schedule of events is planned:

- Draft Number 2 is being reviewed by the public and the National Committee on Uniform Traffic Control Devices (NC), and closure date for receiving comments is March 31, 1991. The NC's and public's comments will be reviewed and incorporated as appropriate into a final draft.

- By September 1991 the FHWA expects to publish a Notice of Proposed Rulemaking in the Federal Register and seek comments on the final draft.

- The FHWA expects to publish a final rule for the new Part VI in November 1992. Comments on the final draft will be reviewed by FHWA and incorporated as appropriate.

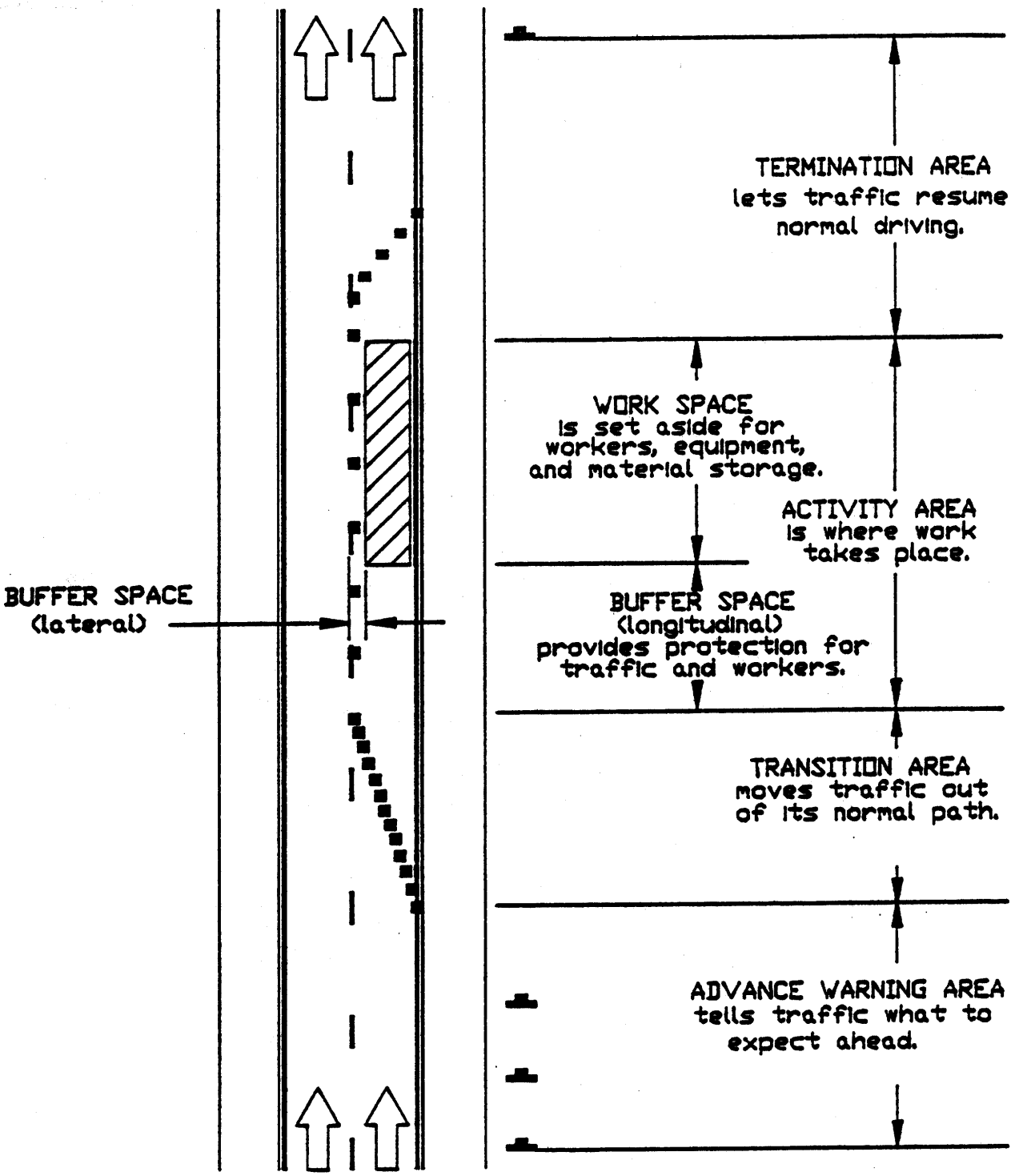


Figure 1 - Areas in a Work Zone.

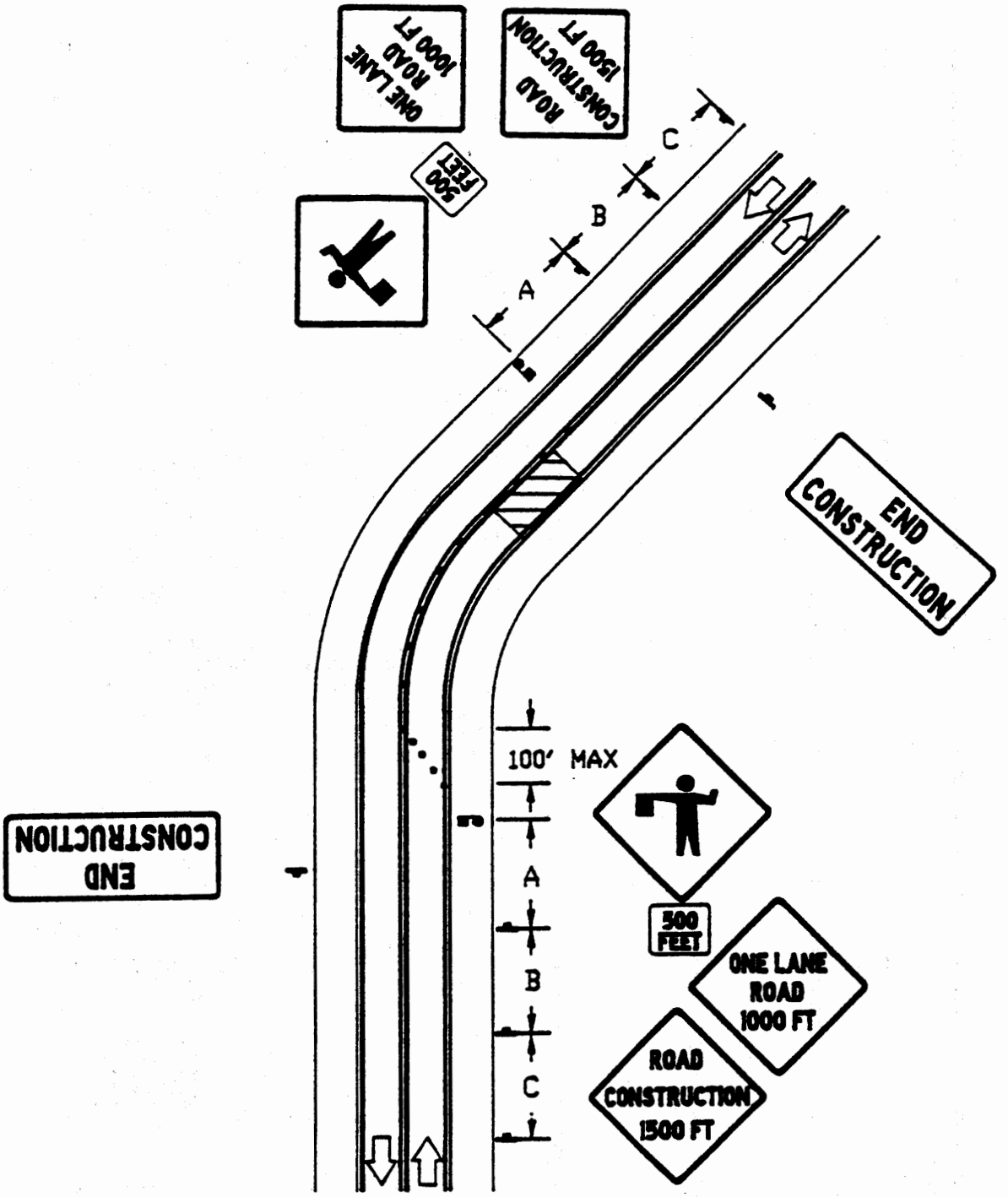


Figure 2 - Lane closure with flagging.

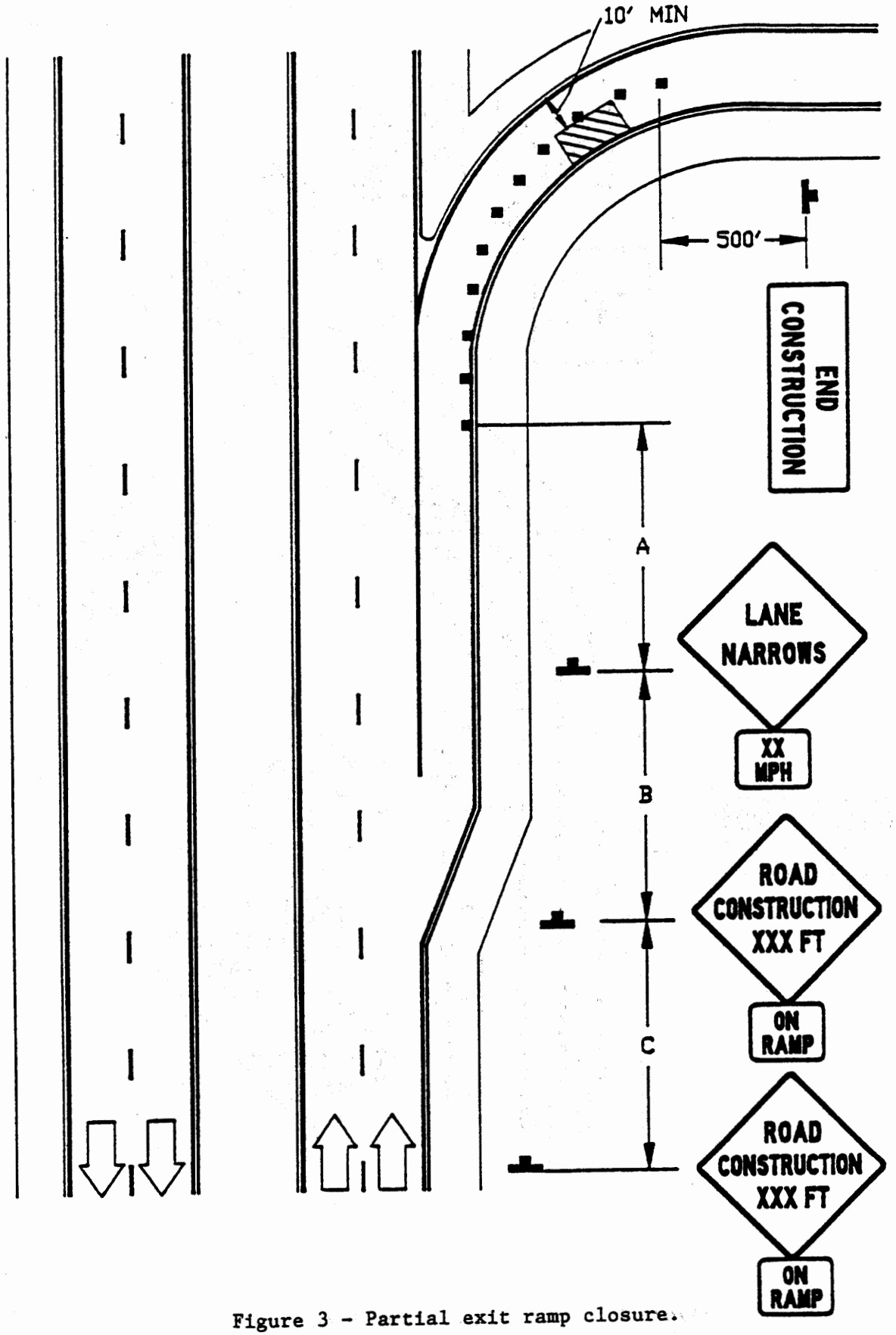


Figure 3 - Partial exit ramp closure.

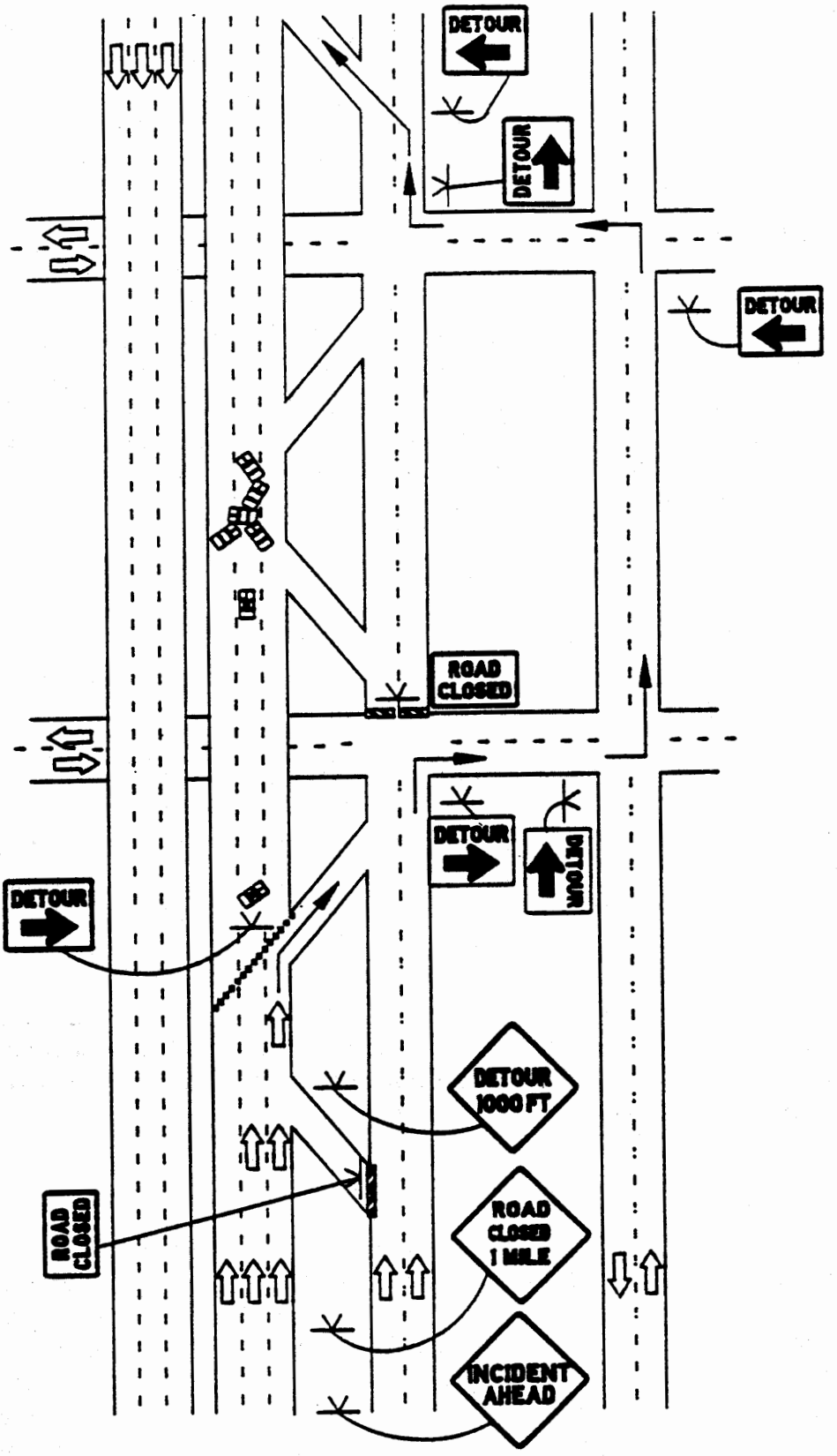


Figure 4 - Emergency Operation - Short-term road closure.

CAUSES AND PREVENTION OF TORT LIABILITY IN WORK ZONES

Russell M. Lewis, Ph.D., P.E.
Consulting Engineer

INTRODUCTION

Tort liability has been a growing concern for public transportation agencies and highway contractors during the past few decades. A recent analysis of tort liability among the States divulged the following statistics for 1988. Only 8 States had sovereign immunity as to torts with 30 other States having some limited form of immunity. Twenty States reported that they had found it necessary to increase the number of lawyers representing their agencies. Pending tort claims totalled $14,948,906,000. In fiscal year 1987, tort liability judgments and awards paid totalled $34,518,000 and an additional $58,602,000 was paid as settlements; thus, the total for tort payments was $93,200,000.

CAUSES AND ASSOCIATED ISSUES

Principal Reasons for Concern

Tort liability cost is a measure of human devastation. The moral ground for its reduction comes before fiscal concern. Liability cases are filed after accidents in which people incur injuries. Governmental agencies have an obligation to operate public highways in a manner that will, within the realm of technical feasibility and to the extent supported by public policies, provide a system that is reasonably safe for the traveling public.

Secondly, tort liability considerations are important to highway agencies because they represent potential expenditures in the form of judgments that must come out of limited financial resources. Additional costs are incurred in employees' time and expenses which must be expended in the agency's defense.

Ability to Achieve Safety

By its very nature, the highway system is replete with hazards. In the United States there are approximately 181 million vehicles operated by highly variable drivers performing under all sorts of conditions. Vehicles varying from motorcycles to tractor-trailers operate on facilities ranging from land-access roads to freeways. This highway network exists all over the countryside, and travel takes place in all kinds of weather, 24 hours per day. In response to the public's demand for mobility, we have created a system having almost universal personal access. Its annual use is 1.91 trillion vehicle-miles of travel, and there are many opportunities per mile for motorists to get into trouble.

Examining the highway system, it is evident that there is virtually no control over the driver, and only limited control over the vehicle. For the third element, the roadway, highway agencies have a high level of control, as long as they do not interfere excessively with traffic. The public insists upon mobility regardless of difficulties in maintaining the system. Therefore, safety is a comparative attribute that cannot be attained completely. Accidents can not be totally eliminated and are, in fact, inherent in the system.

Special Problems at Work Zones

Work zones pose special problems that increase the hazard potential for road users and workers. Work zones surprise drivers; they do not expect work zones to be there. Considering travel mileage, work activities are rare events. Temporary traffic control requires changed and unusual travel patterns which may confuse drivers. Additional hazards may be present in the forms of fixed hazards, equipment, excavations, drop-offs, etc. Dirt and debris may reduce visibility and decrease vehicle performance. There may be distractions and conflicting information. Capacity restrictions may create safety problems and driver impatience.

If the premise is accepted that highways are dangerous, it must be concluded that working on such facilities is even more so, especially when the work must be performed under traffic. Workers are often unprotected from erring motorists.

Regardless of how well the work is performed, given sufficient time and traffic volume, some accidents will inevitably occur. Moreover, considering today's legal climate, serious accidents will likely result in claims.

Difficulty in Defending Claims

The ability of public agencies, contractors, and others to defend such claims is limited, and the situation is deteriorating. A new social concept of justice has evolved, and there is an increased propensity for juries to favor injured parties. Laws related to tort liability have undergone changes which have greatly increased the ability of plaintiffs to seek redress. Publicity from successful suits creates a snow-balling effect creating more litigation. This, in turn, has resulted in increasing the expertise of attorneys specializing in highway torts.

The problems encountered by the defense in highway tort liability actions are formidable. The plaintiff's case can be directed to one specific location and point in time when the accident occurred. The defendants, however, may have to justify their continual actions over the entire system to show why limited resources were not allocated at the point in question. Furthermore, public agencies should recognize that in court they will be held to a much higher standard of care than the traveling public. The odds are that some of these claims will be successful, and the cost of such settlements, judgments, and awards can be very substantial.

PREVENTION

Many good engineering and work practices are useful in enhancing an organization's defensive posture and mitigating liability. Primary recommended actions are listed below.

Accident Avoidance

To the extent possible, accident avoidance is the best claims-prevention technique. Helpful measures to reduce driver-caused accidents include furnishing proper information, then providing time and space for motorists to recognize and correct errors before they become catastrophic. In terms of mitigating costs associated with liability, priority should be given to accident-reduction measures directed towards fatal and serious injury-producing accidents.

Waiting until an accident occurs, however, may be too late to take corrective action. Field personnel need to be aware of operational problems and be able to identify accident potential. Inter-vehicle and vehicle-device conflicts and near misses may indicate deficiencies in the traffic control zone. Brake lights, skid marks, ruts, and damage to traffic control devices provide evidence of operational problems.

Injury Reduction

Injury reduction can often be achieved by using new and/or improved devices, equipment, and techniques. Soft and light-weight channelizing devices that improve dynamic performance upon impact are available. Such devices reduce damage and loss of control potential to impacting vehicles. They also reduce injuries to workers and bystanders who may be hit by flying debris.

Pavement markings are especially useful for temporary traffic control. First, the view presented by the pavement itself ranks high as an information source for drivers, and pavement markings fulfill this basic need. Pavement markings are extremely effective in providing directional guidance, especially where path changes are implemented, such as in tapers, shifts, and diversions. As compared with channelizing devices, pavement markings have excellent durability and impact performance. There are no reported instances of pavement markings being knocked down, coming through a windshield, or flying through the air and injuring a worker. Raised pavement markers are more effective than standard striping and may be easier to remove.

Temporary barriers are one of the few devices that exert positive control over traffic. They can greatly enhance motorist, worker, and pedestrian safety by physically preventing vehicular traffic from entering a hazardous area. In situations involving high speeds, high volume, high hazard levels, and long-term activities, the use of barriers is often warranted and cost effective from a safety viewpoint. In addition, it has been found that barriers may be economical even without the consideration of safety. Once installed, temporary barriers are practically maintenance free as compared with other channelizing devices.

Another device that has great potential for injury reduction is the energy attenuator. Portable crash cushions are now readily available for both temporary and mobile use in work zones.

Inspection and Maintenance

Highway agencies and contractors are obliged to be aware of conditions existing on the facilities for which they are responsible. Under the concept of "constructive notice," the duty to act may arise when the agency should have known of the existence of a situation. Many factors tend to degrade highway work zones. Temporary devices are readily displaced by vehicular contact, wind, and work operations and may be subjected to destruction, vandalism, and theft. Dust, dirt, and grime may coat devices and reduce their legibility. Malfunctions and burnouts are common.

On construction projects, it has been found that the major deficiency is not the planning, design, or installation of the traffic control zone. Rather, it is the failure to maintain adequately the zone throughout the construction period. Evaluation inspections should be performed immediately following the initial installation and after each subsequent modification of the zone. Maintenance inspections and routine servicing of the traffic control zone need to be performed regularly.

Accident Investigation

All major accidents should be treated as potential claims. Accidents at work sites are especially bothersome, as the work activity is almost invariably completed or at least in a different phase before a suit is even filed. Much of the evidence is perishable, and, by the time the suit is in hand, the information is often long since gone. Police accident reports cannot be relied upon to provide the type of information needed for an effective defense. Such reports typically describe only what was found at the accident site itself and the final resting place of vehicles and injured persons. To show that the traffic control zone was adequate at the time that the accident occurred, data must be obtained as to all the devices that existed in the traffic control zone from its beginning up to and including the accident site.

All accidents should be examined from the viewpoint of what improvements in work zone traffic control procedures can and should be implemented which might preclude this or a similar accident from happening again. This requires a review of the accident history together with the characteristics of the traffic control zone. Such analyses should be performed by trained and knowledgeable personnel. Considering the relatively short duration and changeable nature of work activities, these investigations must be completed in a timely manner outside the normal accident review process, which is typically performed on an annual basis.

Standard of Care

Negligence is the failure to exercise such care as a reasonably prudent and careful person would use under similar circumstances. The main issue in tort liability is the care with which highway responsibilities are exercised. If conduct falls below a reasonable standard of care, then the responsible persons and/or organizations may be held liable for injuries and damages which resulted from such conduct.

Many items of information may be brought into court to aid in establishing the prevailing standard of care. One of the strongest types of evidence will be the agency's own documents. Standards and guidelines adopted by the agency may define in detail the minimum requirements. A reasonable person would follow such rules and directives. Other pertinent documents include manuals and standards of a superior agency (Federal/State or State/local agency). When work is being performed by contract, the contract documents--plans, specifications and estimates--set forth the fundamental requirements as to acceptable performance.

Procedures used by other agencies may be used to establish the state-of-the-art. Guides developed by national and professional organizations show reasonable performance as defined by the profession. Examples of such groups include the American Association of State Highway and Transportation Officials and the Institute of Transportation Engineers. Engineering texts, professional journals, and research publications also may be cited. Lastly, there is the opinions of experts.

Changing State-of-the-Practice

Actions that constitute acceptable performance change with time. Research findings, the availability of superior devices, and the recognition of the need for and advantages of improved procedures all have an effect upon how a reasonable and prudent highway engineer would act. A prime example of change that has occurred during the careers of many of us is the use of arrow panels. In the 1970's they were considered to be merely supplementary devices. Today, they are generally considered to be a basic necessity for lane closures on high-speed, high-volume facilities.

We must be alert to other changes that may be underway at this time. Years ago a practice was instituted in which shadow vehicles were used in conjunction with a slow-moving operation or lane closure on a high-speed roadway. Such protection vehicles have been found to be effective in enhancing worker protection, which means that we have a history of them having been impacted. Naturally, such a formidable object poses a significant hazard for motorists. In response to this problem, the highway industry has developed portable truck-mounted energy attenuators. With such techniques and equipment available, procedures need to be reviewed.

Defensive Stance

Because some accidents are inevitable on our highway systems and cannot be completely avoided, it is essential to prepare for inevitable claims. Activities need to be conducted in a manner that lays the groundwork for an effective defense, for use whenever needed.

If it is necessary to deviate from an agency policy or manual, such departures should be approved at the same level that developed the policy. Furthermore the reason for the change should be documented. Where "engineering judgment" is utilized, the persons doing so should have the requisite knowledge and training to make such judgments.

Comprehensive training at all levels to assure technical competence and protective performance is one of the best safeguards available. Employees must be made aware of the safety aspects of their activities and must be familiar with agency policies and procedures. The need for training arises from several factors, including revisions in work procedures, changes in materials or equipment, and the inevitable turnover in personnel.

Good Performance and Proof Thereof

It is essential that work be performed properly and in accord with all applicable requirements. But these actions alone may not be sufficient for an adequate defense. All parties to the work must be prepared to prove in the courtroom that they performed properly in the field. The key to this is good documentation.

There is a general concern that written records will be obtained by plaintiffs under the rules of discovery and used against the agency. If such documentation is compiled properly, that argument is not sound. The point is that if the agency is acting negligently, it will likely lose cases regardless of its documentation. If it is performing adequately, documentation is essential to establish that fact in court.

Written accounts describing the basis for a decision can be invaluable to anyone subsequently reviewing the decision-making process. It also tends to insure a more complete consideration of all relevant factors. Good documentation is not only helpful in establishing reasonable conduct; it may be critical in proving such defenses as design immunity or discretionary conduct. Juries may well discount verbal testimony made at the time of the trial, considering them to be rationalizations or self serving. Written materials prepared at the time in question will carry far more weight.

Proper documentation requires organization and effort. The lack of standard forms, uniform procedures, and review by superiors also contribute to inadequate documentation. Problems caused by poor or nonexistent documentation include the following:

- Difficulty in demonstrating the adequacy of the agency's performance.

- Inability to disprove plaintiff's contentions.
- People involved with the project may not recall essential information and/or events.
- Responsible persons may no longer be available to testify.

Effective documentation records facts not opinions. It must be prepared in a timely manner, signed, and dated. In addition, it needs to be filed in a manner facilitating retrieval. Photographic techniques are especially useful in showing the manner in which the temporary traffic control zone was set up at a work site.

SUMMARY

Improving safety at work zones and mitigating risks associated with tort liability are two important and challenging tasks. Highway agencies and contractors must recognize the inherent problems at highway work zones and must utilize good, current, and prescribed devices, techniques, and procedures. The work must be planned and performed as a well-reviewed and documented process. The key to an effective defense is being able to show that all decisions and actions were based upon accepted principles and procedures and that adequate checks and inspections were performed to insure proper implementation.

CONTRACTING PROCEDURES FOR WORK ZONE TRAFFIC CONTROL SYNTHESIS OF PANEL DISCUSSION

The panel included: Larry C. Smith, Federal Lands Highway Office; Thomas Hicks, Maryland State Highway Administration; Richard A. Dun, Hubbard Construction Co.; and I. Sharon Fischer, Priceless Sales and Services, Inc. The group discussed contracting procedures for traffic control in work zones that will promote safe, successful completion of a job. Discussed were: division of responsibilities and liabilities between the agency, the contractor, and subcontractors; training; methods of payment; dealing with unforeseen circumstances; chain of command; law enforcement; and teamwork.

Larry C. Smith, Federal Lands Highway Office, presented the Federal perspective on contracting procedures. He noted that Federal contracting procedures should give the agency the necessary flexibility to react to and demand the traffic control necessary to maximize public and worker safety. His key points included the following:

- The Federal Lands Highway Office sets up a traffic control plan for every project. All traffic control plans follow MUTCD, but each varies depending on the size and complexity of the project.

- Federal Land's Highway Office Specifications are geared to end-result, with the methods generally left to the contractor's discretion. There are exceptions for high volume projects.

- Every contract for high volume projects contains a specific, detailed traffic control plan, including staging, limitations, work hours, and operations. Such contracts are specific in method and control of operation, but the objective is to get the work done, not to be involved in day-to-day management of traffic.

- A traffic supervisor is named in each contract, and he or she is responsible for day-to-day operations.

- Both lump sum and individual pay item methods of payment have a place in traffic management.

- Lump sum payment requires a well defined and fairly firm traffic control plan in the contract. Lump sum is, therefore, only appropriate for simple projects when traffic control is set up one time only and is not likely to change. Lump sum puts a higher risk on the contractor because the contractor has to forecast changes in traffic at bid time.

- Individual pay items are used almost exclusively with work rehabilitation, with the exception of some small jobs. Individual pay item payment provides flexibility to

contract administrators. Day-to-day changes can be made without dispute with the contractors.

- The individual pay item method adds risk to the agency because the contractor is in control of the number and speed of the operations. This method reduces risk for the contractor because it is easier to bid and generates fewer disputes.

- Using time gives the highest risk to the agency because the agency does not have control over the contractor's operations--how many people are on the job, or what equipment is used. Time is usually used for flaggers and pilot cars to ensure quick response. The time method is also used for flashing arrow boards and variable message signs when they are needed only for a specific short period of time to set up or move traffic patterns.

- Paying for traffic control by time is administratively time-consuming because the contract administrator must keep records on a daily or even hourly basis. The time method gives the agency maximum flexibility to carry out the traffic control management plan.

- The preferred method of payment is through individual unit prices bid by the contractor to provide a particular traffic control device, including set-up, moving the device around, maintaining it, and replacing it when necessary, for the duration of the job. This method shares the risk between the government and the contractor.

- By paying for traffic control by unit basis, we pay directly for what we think is necessary whether it was anticipated or not.

- The contractor and the agency must monitor and inspect traffic control on a regular basis during daytime and nighttime whether operations are underway or not.

Thomas Hicks, Maryland State Highway Administration, addressed the two-way dealings and problems between the State Highway Administration and the contractors. The challenge, he said, is to provide safety, economy, flexibility, and mobility. Because Hicks submitted a complete paper that appears after this synthesis, abbreviated highlights only are included, as follows:

- Highway agencies are making do with less money and less manpower while traffic demands are increasing, resulting in greater hazards for both the public and workers. Highway agencies are subjected to increased regulations--environmental and others. The situations are more demanding, and we have a public that is less compliant.

- Specifications and special provisions for work zone traffic control devices must be comprehensive, clear, understandable, and detailed.

- All participants in the process are members of a team. Interrelationships of the parties in the work zone have to be understood, particularly relating to the handling of unforeseen and emergency conditions and the contingencies to deal with them.

- Contracts should cover the hours of operation and what happens if there is noncompliance with specifications, as well as the method of measuring the basis of payment, including the handling of overages and underruns.

- With bid items, unit pricing should be used to the extent possible so that it is clear what we are paying for. Unit pricing allows for handling unanticipated needs without a lot of renegotiating. We need to spell out how we know that something needs to be maintained, repaired, or replaced, and who pays for it.

- Every project should have a traffic manager, a contractor's person, who is trained through ATSSA or another program.

- Our project engineer is our lead engineer who is responsible for all aspects of the projects. He or she has the final say on work zone traffic control issues.

- The district traffic engineer is the agency's top traffic person, unless policy needs to be addressed by central office approval. The district traffic engineer must approve all significant changes to the traffic control plan. Significant changes might include things like the unanticipated building of a detour or running traffic across the median.

- Traffic control plan inspections should involve technical teams, which include representatives of the highway agency, the contractors, FHWA, and law enforcement, if needed. Nontechnical people from the agency or representatives from AAA should be sent through the work zone to find out what's good and what needs changing.

- Law enforcement must work with the engineers.

- More States are passing regulations that allow for higher fines for violations in work zones than on the open highway.

Richard A. Dun, Hubbard Construction Co., presented a look at contracting from the general contractor's perspective. He made the following observations:

- Highway agencies and engineers have as their primary objective maintaining a safe, efficient highway system, while the general contractor's objective is to make

money. It's our sole reason for being in business; however, unsafe practices, unsafe construction techniques, and unsafe work zones lose money. It is incumbent upon us to make sure we are working safely because nothing loses money faster than accidents.

- The purpose of contracts and subcontracts is to delineate, appropriately and specifically, the responsibilities and liabilities of the players in the game--the owner, the engineer, the contractor, and the subcontractors.

- The goal of contracts and subcontracts is to structure a knowledgeable and cohesive team that can successfully complete a project. The better job we do of putting together the contracts and adequately describing what we want done and whom we want to do it, the more chance we've got to successfully complete a project.

- Cost-effectiveness in staging is not as immediate to the owners and engineers as it is to the contractor. Properly written contacts and subcontracts and plans that adequately describe the work help minimize disputes, claims, and loss of money on all sides.

- Unit price payment and lump sum payment both work with contracts and subcontracts.

- Unit price payment is essential in maintenance of traffic. Contractors exist in a competitive bid market in the U.S. in all road construction. In that market, that which you don't specifically pay for, you're not going to get. You need to pay by unit price so that you can ensure that the proper devices are going to be on the job to ensure a safe project and to guarantee that you're not going to have arguments.

- The lump sum method of payment can be used to handle the general work zone maintenance, the clearing of debris, the maintenance of steady-burn lights on barrier walls. Lump sum allows such items to be fully paid for, including set-up, relocation, and maintenance. What is included in the lump sum must be described exactly so that there are no mistakes.

- The maintenance of the traffic plan is usually provided in the design package for bid purposes. It is what the contractor uses and what the traffic control subcontractor uses to put together the bid. Unfortunately, the plans that are provided to us rarely work the way they are put together. Why not? They are put together by a designer--not necessarily the engineer who signs--but a designer working under him, who may be limited in on-site construction experience. Inexperience leads to some items in a traffic control plan that are not good in concept. More importantly, the maintenance of traffic plan is put together before the construction process by someone who's got an entirely different concept from

the contractor in terms of the sequencing of the construction work or in terms of the cost of doing the construction operations.

- We should get more contractor input into the design stage, up to, and including going to design/build. The more input you've got from the guys who are going to do the work, the better your plan is going to be at the outset, and the fewer changes that will have to be made down the line.

- Responsibility is delineated in the contracts at all levels of government. The contract should adequately describe the responsibility of the owner, the engineer, and the contractor.

- On the job site, we need trained, experienced personnel, who carry out the orders of the contract to specifications. We have to provide a trained and experienced supervisor and trained and experienced personnel. As an owner and engineer, there's a responsibility to provide trained, experienced inspectors, project managers, and administrators.

- We need consistency in all work zone traffic safety requirements. There is no consistency in the enforcement of using safe practices for municipal workers and for private utilities workers, as there is within the construction industry.

- We need increased law enforcement in the work zone. No one will obey a 45-mi/h speed limit when nothing's going on. By the same token, when you've got a construction zone in use and people are speeding through it at 75 and 80 mi/h, which is typical in Interstate construction projects, something is wrong. It will lead to a fatality sooner or later. The only way we can curb that is to get more and stricter law enforcement within the work zone.

- Increased fines within the work zone is an excellent idea.

- We need common sense in the field. We've all got books, manuals, and procedures, but they can't answer all the questions. You almost always find a different set of circumstances facing you. We've got to approach those situations on the job with the idea that our goal is to complete a project successfully; our interim goal is to do that safely. A common-sense attitude and teamwork can make that happen. While changes in Florida must be approved by the engineer, if you build in reasonable steps, you get a reasonable result.

I. Sharon Fischer, Priceless Sales and Services, Inc., called for teamwork and responsibility from all participants to achieve safety in the work zone. She pointed out problems she has encountered as a subcontractor, who is often thought of as being on the bottom of the rung. Her complete paper follows this synthesis. Key points of her presentation were as follows:

- A project is supposed to be a team effort; unfortunately in real life that is not the way it always works. Everyone in the process must fulfill his or her responsibilities properly. We need the contractor, engineer, and owner all working together to do what is right and demand what is right from a safety standpoint. Last year 2,500 people died on work sites.

- When every dollar you spend has to count, why not go with the best. The competitive bid system worked for us for many years, but does that mean that it will continue to work for us? Obviously not, or we wouldn't have had 2,500 people die on work sites in 1990. That's a startling fact.

- When selecting contractors and subcontractors, agencies should consider the qualifications of the persons they are dealing with, their experience--not just whether they can get the job done and bring it in on time, but the quality of the job.

- Owners should prequalify the general contractor, and the general contractor should prequalify his or her subcontractors and suppliers. We, the subcontractor and the suppliers, are at the very bottom of the tier, and it shouldn't be the bottom rung because without us you don't get the project done.

- It costs money to train personnel. Overhead is greater for contractors who have a safety program, tool box talks, a communication program for employees, and continuing education. All things being equal, who'll be the low bidder? The guy with no overhead. A central clearing house for contractors, subcontractors, and suppliers might be the answer.

- It should be easier to change things, such as a speed limit in a work zone if there is a problem.

- For years the relationship between contractors and subcontractors was master/slave. Fortunately, many contractors now recognize it is a team effort. We subcontractors have made a concerted effort with general contractors to understand each other's problems and understand the other's rights.

CONTRACTING PROCEDURES – A STATE'S PERSPECTIVE

Thomas Hicks
Deputy Chief Engineer-Traffic
State Highway Administration
Maryland Department of Transportation

GENERAL

State Highway Departments have as their primary objective the operation and maintenance of a road system that is efficient and safe. As this objective relates to work zones, all organizations represented at this symposium share the responsibility of providing the performance levels, tools, and resources that assure the travelling public and the highway worker a highway operation of optimum efficiency and safety.

Today we are all being called upon to perform in increasingly more difficult circumstances--reduced resources, manpower, and dollars; increasing traffic loads; working under traffic; a more demanding and less compliant public; increased regulation of our activities; and an increasing deterioration of our older road systems. None of these things was unexpected, except, perhaps, the rate of their occurrence. They are part of the game that we play, and they form the challenge that our team must now contend with.

The word "team" is important. No longer can we as individual agencies, government and private, perform without close coordination and intricate involvement of mutually dependent programs in work zone traffic control (WZTC). Highway agencies, contractors, subcontractors, suppliers, police, local governments, media people, and others have leading roles in "making it work" in our WZTC efforts.

Before getting into the several elements of WZTC that should be explored and discussed in the detail needed to help us better understand our program needs, and in order to achieve our common objective of safety in the work zone, we should first recognize and admit that we're not there yet. While we've made major gains in improving work zone safety in recent years, the feeling here is that we still have a long way to go to provide the level of public and worker safety that we would feel is acceptable. It is somewhat ironic that on one hand we have a very impressive array of knowledge, standards, texts, tools, and devices, but, on the other hand, we have so far to go in putting it all to good use. In a nutshell, we have not done what we know needs to be done. Why haven't we? That's what we need to review and discuss now.

In the sections that follow the various elements of work zone traffic control that deal with contracting procedures are listed. Within each section are issues that are briefly described and noted as being in good shape or in some way unworkable or in need of

help. At the end is a list of ideas and suggestions for implementation, or consideration, by FHWA and the symposium participants for immediate improvement of our various WZTC situations.

WZTC ELEMENTS

Specifications and Special Provisions

The need here is to have complete and comprehensive specifications that describe in sufficient detail the various WZTC elements, as to responsibility for performance, needed approvals, material specifications, required training/certification, interrelationships with others, contingencies, coordination with adjacent projects, changes in the traffic control plan, major unforeseen disruptions in the approved traffic control plan, traffic regulations, use of law enforcement, handling of noncompliance with specs, project shut-downs, incentives/disincentives, hours of operations, record-keeping, public relations/news media, handling of incidents/accidents, method of measurement of work performed, and the basis of payment of this work.

Most failures of the system to work well stem from having to make significant changes in an already approved Traffic Control Plan (TCP) due to unforeseen circumstances. The difficulties are mostly due to being unable to neatly "pull it off," that is, get the traffic control changes approved by everyone and have the specs written in a way that permits quick implementation. This means planning in advance for contingent items and having them covered adequately for measurement and payment.

Another area in which the specifications are usually weak is in the handling of deficient devices. Methods are needed for determining the level of device adequacy, time requirements need to be set for replacement of inadequate devices, and a process for shutting down the project for failure to remedy unsafe situations needs to be clearly set forth.

Bid Items

To the extent possible, each individual WZTC task and control device should be individually measured and paid for. The extra paperwork that may be needed is more than offset by the advantages of having a clear understanding that each action will be accurately measured and paid for promptly in well defined terms. Unanticipated needs can be provided without renegotiations and undue hassle, making the accounting simpler for the highway agency, and clearer to the contractor, subcontractor, and supplier as well. Errors and miscalculations in the original development of the TCP can be recognized for avoiding such mistakes in the future.

The unit prices for both services and devices should reflect the requirements of the highway agency to have the proper and legally sufficient traffic service being provided at

all times in the work area regardless of any extenuating circumstances. All traffic control devices must be adequately maintained and replaced when no longer serviceable, and standby devices must be expeditiously placed into service when others malfunction or are otherwise knocked out of service. The contractor and/or subcontractor must provide the timely monitoring of the work site to see that this is done.

Certain traffic control devices and services lend themselves well to being measured and paid for through unit pricing while others seem to be better handled through a "lump sum" type of maintenance of traffic item. It would be helpful for the highway agencies to have more information on other States' experiences on this, and perhaps a task force of AASHTO, FHWA, ATSSA, ARTBA, and other affected groups could provide this information.

Traffic Control Plan (TCP)

While having and implementing a traffic control plan for State highway projects is not now an issue, having TCP's for local road projects and for work done along public highways by utility companies, developers, and others is a real problem. The effects of not having good TCP development and compliance within these lesser projects are threefold. First, the public is not being provided uniform and consistent traffic control device usage which leads to misunderstanding and noncompliance. Secondly, public safety and worker safety is jeopardized, and, third, costs are increased for contractors and suppliers through the handling of nonstandard devices.

The development of the TCP should be an interdisciplinary, teamwork effort, either in the initial development, or in its review prior to implementation. The avenue should always be there for changes and modifications to handle unforeseen or emergency condition changes. As part of the project wrap-up, comments should be solicited from contractors, subcontractors, and traffic control device suppliers on the appropriateness and adequacy of the TCP elements.

The TCP provisions must take into account stage construction of the project, the placement of new permanent traffic control devices within the project (and their applicability at the time of installation in consideration of the other work still underway), the maintenance of existing traffic control devices (those in place before construction began), the devices needed for highway conditions beyond the project limits, and the use of parallel routes for necessary or voluntary diversions.

Probably, among all of the WZTC elements, the TCP--its development and implementation--is the most important.

TCP Subelements

Every agency having a role to play in the traffic control scene should have an opportunity at some point to contribute to the development and/or implementation of the

TCP. This includes the highway agency, the contractor, law enforcement, local jurisdictions, fire and rescue, consumer groups, public information, news people, mass transit, utilities, and metro traffic. Depending upon the extent of the project and its effects upon traffic movement, some agencies will be in on the TCP development while others will usually just be told about the plan. Comments, however, should be solicited and willingly received from all quarters, particularly in the way of critique to see what went well and what did not.

A traffic control plan can be quite complex, and latitude must be provided in the numbers and types of traffic control devices being used in the project to allow the contractor to provide the correct devices at the appropriate times in consideration of constantly changing traffic conditions. Unforeseen and emergency conditions may arise due to changes in the construction staging or due to major incidents. Real-time traffic control and credibility with the public is everything. Quick and near instinctive contractor response is to be striven for, and the highway agency must provide the conditions and provisions that make it possible.

The traffic control plan must take into account adjacent projects and complement the TCP's of those work areas. Similarly, the project traffic control strategies must recognize the capability of the local road system to handle any extra traffic that may be diverted because of a capacity loss through the work area. If the total WZTC program is to succeed, the inconvenience to the public with the resultant congestion and poor safety conditions must be minimized. Not to do so results in public disrespect, lack of support for our highway improvement programs, increased costs, increased accidents, and less safe conditions for the road worker.

Traffic Manager

Every highway construction project should have a traffic manager, someone responsible for overseeing completely the implementation of the TCP. The traffic manager is the contractor's representative who ensures that the provisions of the specifications are being followed, that device usage and maintenance is timely, that unforeseen situations are promptly dealt with, that questions regarding the TCP are directed quickly to the correct person/office, and that all problems are handled with dispatch from the contractor's perspective. The traffic manager coordinates the TCP activities with the subcontractors and suppliers and is the chief spokesman on the project representing the contractor.

The traffic manager must be qualified to fulfill the role and should be certified through training and completion of appropriate courses, such as those offered by ATSSA.

Every major construction project should have a full-time traffic manager, while those projects of a lesser type may either have one traffic manager for several such projects or a traffic manager having other tasks, but with the overseeing of the TCP being the primary task.

Project Engineer

The highway agency assigns an engineer to oversee the project. This engineer is responsible for all aspects of the project of which the implementation of the TCP is one--the most important one. There is no question that preserving public and worker safety is far and above the most essential task of the project engineer.

The project engineer must be fully knowledgeable in all aspects of traffic control, and, in most instances, he or she is the final authority on traffic control issues within a project. On large or more complex projects, the project engineer relies on project inspections to monitor traffic conditions within the work site. One or more inspectors should be assigned the task of routinely inspecting all aspects of traffic control within a project, recording their findings, and discussing them with the contractor's traffic manager. Inspectors must also be knowledgeable in the subject of traffic control, and the highway agency should provide adequate training for inspectors to assure their proficiency.

District Traffic Engineer

The district traffic engineer has the responsibility of developing or overseeing the development of the TCP. The district traffic engineer is usually the traffic control authority at the district level and handles all interpretations of traffic control issues. Frequent field reviews of TCP's should be undertaken by the district traffic engineer accompanied by the project engineer, or his or her representative, and the contractor's traffic manager.

All questions directed to the project engineer that cannot be completely responded to are directed to the district traffic engineer who is a fully qualified traffic engineer. More complex traffic control problems and those involving agency policy are referred to the agency headquarters traffic engineer unit for advice and guidance.

The district traffic engineer should be responsible for approving all significant changes to the TCP and for assuring that the TCP is fully and correctly implemented for major construction projects or activities prior to the commencement of the related work.

Field TCP Inspections

Field inspections of TCP's for effectiveness and reasonableness should be undertaken by teams of engineers and nonengineers with an assignment scope and frequency of visit commensurate with the extent of the project and its effect upon traffic movement in the area of the work site. Such teams should consist of highway agency, law enforcement, and contractor representatives, from both central and field offices, who may not necessarily be familiar with the work site.

The team may be joined by nonengineers who are drivers but not overly knowledgeable in traffic control, or a second team of such persons should be formed for

the TCP field review. The findings of both teams should be reported to the project engineer immediately so that identified issues may be promptly dealt with.

Team reports should also be recorded for review by district and central office staff for improving the overall process. Likewise, such reports should be given to the contractor for use in developing improved traffic control techniques.

Law Enforcement

In this day of increased work activity under fairly heavy or unexpected traffic conditions, the use of law enforcement officers has been found to be effective in creating a greater awareness and, consequently, greater caution on the part of the travelling public. National guidelines for such use and a summary of others' experiences would be helpful as a basis for the use of law enforcement officers at the work site.

Traffic Regulations

Generally, extraordinary traffic regulations governing motorists' actions should be avoided, as pointed out in the MUTCD fundamental principles. There are situations, however, when special regulations can serve a useful purpose in increasing the level of safety in the work site. Such regulations should be based upon need, and they and the devices used to convey them to the traveller should fully meet the five basic requirements of traffic control devices set forth in the MUTCD.

Several States have enacted, or plan to enact special penalty rates for traffic law violations in work zones. For the sake of reasonableness and motorist credibility, the highway agency should be assured that such regulations are indeed justified on the basis of normally accepted standards for such determinations and that the traffic control devices posted to regulate traffic and all other devices in the immediate area fully comply with the MUTCD and other standards governing their use. Such traffic regulations should be posted only when the warranting conditions exist.

Traffic Control Devices

Traffic control devices are the signs, barricades, channelizing devices, arrow panels, signals, pavement marking, lighting devices, and other indicators that are placed along the highway in advance and within the work area that warn, guide, and regulate traffic approaching and travelling through the work site. These devices are the means that tell the driver what to expect and what is expected of him.

Traffic control devices should be used and applied in strict conformance with the provisions of the MUTCD, paying particular attention to the fundamental principles set forth in Part VI. Of paramount importance is the maintaining of devices in acceptable condition at all times, and the adjustment and removal of those devices no longer needed.

As pointed out by ATSSA in their testimony to the 101st Congress, provisions should be made in the specifications for the measurement and payment of needed changes, adjustments, modifications, removal, replacement, and relocation of traffic control devices within an ongoing project.

Opening the Road to Traffic

As sections of highway projects are opened to receive traffic, all needed devices should be in place, and unneeded WZTC should be removed. In areas where work activities remain, during those times no activity is underway and no hazards exist, WZTC should be removed, covered, or turned to be out of sight.

Opening the road to traffic is an activity that should be undertaken jointly by the agency's project engineer and the contractor's representative.

POSSIBLE SOLUTIONS TO THE PROBLEMS/NEEDED ACTIONS

Below are noted various thoughts and possible solutions and actions that relate to the concerns noted earlier that will be helpful in providing a more effective WZTC program:

- A clear understanding that safety is #1, public and worker safety.
- Specifications that completely and clearly set forth the project traffic control requirements.
- Unit pricing for most traffic control items.
- Strict enforcement of the spec requirements.
- Utilizing a traffic control device use and application matrix. (See below)
- TCP development/monitoring/critique by all affected agencies.
- Team reviews of the project TCP by technical and nontechnical groups.
- Supporting the three ATSSA recommendations.
- Accident data gathering to determine needs.
- Traffic manager on every project.
- Traffic control device pay items for traffic control modifications, changes, etc.
- Training and certification programs for traffic managers.

- Real-time traffic control information/VMS, Traveler's Advisory Radio (TAR), public relations.

- Law enforcement use in the work zone.

- Continuing research--devices and strategies.

- Task Force--AASHTO, FHWA, ATSSA, ARTBA, ITE, IACP, others, to discuss WZTC issues in each State in a similar type symposium.

Traffic Control Device Use and Application Matrix

A matrix of sorts should be developed, perhaps by FHWA, that provides guidance for the selection of the several types of devices to be applied under varying work zone conditions. The major elements include the following:

- Type of highway (class and geometrics).

- Speed of traffic.

- Type of work activity.

- Proximity to traffic.

- Duration of work activity.

- Relative hazard.

The traffic control device variations would include numbers, sizes, placement, use of warning lights, type of channelizing device, use of special warning devices, use of VMS, use of TAR's, among others.

SUMMARY

The WZTC problems are not insurmountable. Together, we can easily bring about the needed improvements in work zone traffic operations that will assure our customers, the travelling public, and our highway workers optimum safety. Through this symposium and smaller State meetings we can build the basis for a successful nationwide WZTC program.

CONTRACTING PROCEDURES -- A SUBCONTRACTOR'S PERSPECTIVE

I. Sharon Fischer
President
Priceless Industries, Inc.

Everyone who has traveled on today's roads has at some time experienced a delay for a seemingly interminable period, inching slowly forward, only to find upon arrival at the construction site a bunch of workers who appear to be doing nothing. When this occurs, most motorists accuse both the government agency and the contractor for delaying them for no good reason--a mortal sin for those in a hurry to get somewhere. And while those of us in the construction business may look around to see the real cause of the delay, even we must admit that all too often the problem is caused by incorrect signing or poor maintenance.

This is a public relations problem of the first order. It is no wonder that most motorists don't even bother to slow down when approaching and passing through a work zone. Ultimately, however, the real problem is safety.

A growing number of State and local jurisdictions have learned the importance of work zone traffic control for the safety of both workers and motorists. Such owners make safety a common thread running through the entire construction process.

These safety-conscious agencies include safety procedures in the project design and schedule. They require contractors and subcontractors to meet minimum standards of safety in order to bid. They make safety a priority for discussion at every construction meeting. They make sure that safety inspections are conducted regularly and unsafe operations are corrected immediately. Typically, these owners have contracts which state that failure to comply with their safety rules and regulations is immediate cause for dismissal of the contractor and termination of the contract.

PREQUALIFICATION OF CONTRACTORS AND SUBCONTRACTORS

One method owners use to assure safety is simply not to do business with unsafe contractors and subcontractors. A 1982 recommendation from the Business Roundtable's Construction Cost Effectiveness project urged owners to "make safety an important consideration in choosing contractors to bid on projects and review their history of safety performance."

More and more owners, both in the private and public sectors, are prequalifying contractors and subcontractors on their safety records. Indeed, some owners claim that contractors who excel at safety also eclipse their competitors in managing other aspects of their business; a history of safe operations seems to demonstrate that a contractor also

has the management skills necessary to control all of the other components of its operating costs.

An owner's prequalifications criteria for safety may include:

- Past safety performance on the owner's projects.
- Occupational Safety and Health Administration (OSHA) Occupational Injuries and Illness Annual Survey Form No. 200.
- Workers' compensation experience modification rates.

Past Safety Performance on the Owner's Projects

Some safety-conscious jurisdictions monitor, evaluate, and record the safety experience of the contractors and subcontractors on their projects. They may place a safety evaluation on each contractor and subcontractor in their data bases as a reference for selection on future projects. Some owners even require that subcontractors be listed in the bid and retain the right to disqualify the subcontractors if their safety records do not meet the standards established.

OSHA Form 220

Another method jurisdictions may use to prequalify contractors and subcontractors is to review their OSHA Form 200's. OSHA requires that these forms be completed and posted on each job site in February of each year. A typical safety-conscious owner may require a recordable injury rate not exceeding 15 per 200,000 man-hours. Other owners have criteria tied to the lost workday rate.

Workers' Compensation Experience Modification Rates

Some owners prequalify their contractors and subcontractors through the use of workers' compensation experience modification rates. Contractors may be required to have a low or a trend toward lower workers' compensation experience modification rates. For example, an owner may require its contractors and subcontractors to have 1.0 or lower for the previous year, or the three-year trend must be declining with no single year exceeding 1.20.

CONTRACTOR REQUIREMENTS FOR CONTRACTORS AND SUBCONTRACTORS

The contract establishes the basic working relationship and conditions between an agency and its contractors. Clauses establishing minimum safety standards and operating procedures should be incorporated into the contract. A clause also should be included

that assures that those safety requirements are passed through to subcontractors. Such contract clauses may include:

- Minimum training requirements for supervisory and other personnel.
- Mandatory tool box talks.
- Penalties for incorrect signing, poor maintenance, etc.

Training Requirements

Well-trained personnel may be the most important component of work zone safety. Increasingly, safety-conscious owners require their contractors and subcontractors to assure that all on-site personnel have received minimum safety training. Indeed, the Federal Highway Administration's program manual requires that personnel responsible for the work zone traffic control be "adequately trained." At least 12 States now require that contractor supervisory personnel be certified.

In any event, supervisors should be knowledgeable about a broad range of safety issues, including standards and specifications, the contract requirements, maintenance of devices in the work zones, supervising for safety, and conducting safety inspections. Every worker on the job site should be trained in techniques for protecting his safety, his work mates' safety, and the safety of motorists.

Mandatory Tool Box Talks

Another way owners assure that job site personnel are safety conscious is to require contractually regular tool box talks. The first such talk almost always is conducted before work begins on the project. Subsequent talks may be held weekly or even daily, depending on the length and complexity of the project. The talks usually are conducted by a supervisor or a safety specialist.

Penalties

As noted above, State and local governments routinely incorporate in their contracts a myriad of clauses setting standards for safety in the work zone. These clauses address basic issues such as preparation of and adherence to a traffic control plan, enforcement of proper work zone markings, and maintenance of the work zone. However, an owner dedicated to safety through work zone traffic control must do more than establish standards and specifications; it also must enforce those standards.

Historically, State and local jurisdictions have done a poor job of enforcement. Industry groups, such as the American Traffic Safety Services Association, have pushed for stronger enforcement through penalty and/or reward clauses in contracts. Increasingly, agencies are listening.

Most jurisdictions' contracts state that failure to comply with their safety rules and regulations is immediate cause for dismissal of the contractor and termination of the contract. Of course, such dramatic action is not necessary for every violation. But some enforcement mechanism, perhaps in the form of fines or other penalties, should be routinely applied when worker or motorist safety is at risk.

OWNER RESPONSIBILITIES

Of course, contracts bind both parties. So State and local jurisdictions contractually must assume responsibilities for safety in the work zone beyond setting and enforcing standards. These responsibilities, at a minimum, should include:

- Coordination with local law enforcement officials.
- Availability of qualified inspectors.

Coordination with Local Law Enforcement Officials

As part of the government, an agency is in the best possible position to coordinate with local law enforcement officials.

The fact is that the best way to get motorists to slow down as they enter construction work zones is to enforce all posted speed limits. For example, the owner should assure that regular enforceable traffic speed signs are posted, in addition to the construction signs, where feasible.

To ensure motorist compliance with posted speed limits, the owner should coordinate with the local law enforcement agency to create visible police presence. Indeed, some jurisdictions have gone as far as to use off-duty police officers to create that presence.

Qualified Inspectors

One of the most serious enforcement problems faced by owners and contractors is lack of qualified inspectors. Contractors working in State and local jurisdictions across the country complain about the inspectors on their job sites. Contractors consistently demand better trained inspectors who have a thorough knowledge and understanding of the construction process. Just as contractor and subcontractor personnel on the job site must be "adequately trained," so should the owner's personnel. Inspector training should include not only the "textbook" on traffic control plans, but also experience on a job site.

SUMMARY

The successful completion of any construction project relies on a team with a variety of unique and exclusive functions. The members of this team include the owner, design professionals, the general contractor, subcontractors, sub-subcontractors, and suppliers. The conditions under which these team members interact are established through a network of contracts. While the interests of these team members may sometimes diverge, safety is a common goal. Each team member is dependent on the others to achieve this common goal.

THE USE OF POLICE IN WORK ZONE TRAFFIC CONTROL

Captain Terry W. Conner
Arizona Department of Public Safety

INTRODUCTION

This presentation will focus on the essential need for cooperation and coordination between construction contractors, engineers, and law enforcement officials at highway work zones. With an increase in reconstruction-type projects nationally, a similar increase in work zone crashes involving injuries and fatalities needs to be given a top priority to effectively reduce the increasing crash rate and better manage future projects.

Recognition by law enforcement personnel of hazards may lead to a crash within a work zone, and how to best deal with inattentive or disrespectful driver behavior is an important issue for the police. Enforcement is more effective when a cooperative relationship between engineering, education, and enforcement can be achieved.

Highway fatalities have begun to slow, or, in some parts of the country, are lower than previous year totals. Yet fatality and injury crashes in work zones are on the rise nationally. In 1982, 480 deaths were reported in work zones across America. In 1989, the figure was 780. While the 1990 figures are not available, it is believed the National figures will meet or exceed previous records. Action needs to be taken now to dramatically reduce this trend.

THE POLICE ADMINISTRATOR AND WORK ZONE TRAFFIC CONTROL

The chief police administrator in any jurisdiction must be the first police official who is convinced of the need for increased work zone attention. If he is not convinced on the subject, only minimal work can be done and minimal effort can be expended by those in operational positions. The police administrator will be convinced of the need for increased interest, I believe, when he becomes acquainted with the accident picture, especially fatalities, as they increase in work zones.

It appears that in many instances, a tragic highly publicized fatality or two must occur before administrators see the need for work zone inspection and enforcement by their officers. It is hoped that more and more we will be able to interest police administrators before they are faced with these tragic results.

For many years, traffic law enforcement administrators have tackled the traffic law enforcement problems in their jurisdictions through a method called "Selective Traffic Enforcement." Manpower is assigned to locations and times of day in response to types of violations, which are accident causative as indicated by past records. What the crisis in

work zone accidents calls for is a "Selective Preventive Patrol" concept. This would direct police officers to inspect work zones to be certain that signing and design standards are met in order to control traffic in a safe and expeditious manner. As stated previously, this would call for a high degree of coordination between the police administrator and his traffic engineering partners.

Some time ago, Major Tom Milldebrant of the Arizona Department of Public Safety developed an eight-point checklist, which a police administrator, I believe, should use in developing an effective program to ensure safety in construction zones in his or her jurisdiction. The eight points are as follows:

1. Establish ongoing coordination and communication with traffic and maintenance engineers in his jurisdiction.

2. Seek invitations to attend preconstruction conferences.

3. Have appropriate operational commanders and supervisors attend preconstruction and maintenance conferences.

4. Train road officers and supervisors in work zone requirements as specified in local, State, and national manuals.

5. Require regular day and night patrols of all construction work zones.

6. Establish ongoing liaison between project engineers, construction engineers, and local officers.

7. Establish periodic command-level inspection of all construction sites to ensure adequacy of traffic control devices and traffic control.

8. Establish procedures by which discrepancies or deviations from the traffic control plan and/or manual can be reported to appropriate highway officials.

PLANNING

When the police administrator adopts the eight-point plan, either he or some high-level command officer, can begin a regular planning program in conjunction with highway officials. It is important to remember that planning is a time-consuming process, but if properly done, it will pay big dividends in accident reduction in work zone areas.

The Manual on Uniform Traffic Control Devices states, "A traffic control plan in detail appropriate to the complexity of the work project should be prepared and understood by all responsible parties before the site is occupied." Any changes in the traffic control plan should be approved by an official trained in safe traffic control

practices and should be coordinated with enforcement officials who are charged with enforcing the traffic regulations in the work zone.

Experience has shown that even in jurisdictions where law enforcement administrators are brought into the planning process, they are quite often brought in as an afterthought or very late in the process. Experience in Arizona has shown that the earlier police officers and engineers can begin work on planning at work zone areas, the easier it is for both jurisdictions to develop an effective plan and eliminate potential problems when the plan is implemented.

Timely notification is important to those who attend planning conferences. In the past, it has not been unusual, at least in my jurisdiction, for enforcement officials to receive notice of planning meetings and preconstruction conferences either the day of the conference or a day after they have been held. This is not an example of timely notification and does not breed cooperation, coordination, or goodwill.

It is not enough that planning take place at the headquarters level of both agencies. Any planning, which is done at that level, must be passed down the chain of command where it can be implemented and modified as needed at the operational level of both the enforcement and engineering agencies.

TRAINING

Before proper planning can be done and understood by the parties involved, adequate training of everyone involved in work zone projects has to be completed. This is especially important to law enforcement agencies, as in most cases, this is a new area of concentration. Before they can properly conduct their activities, the commander, operational supervisors, and officers must have exposure to work zone standards, devices, and techniques.

A typical training program for field officers begins with securing copies of the jurisdiction's construction traffic control manual. Then, in conjunction with highway engineers, a meaningful training curriculum can be developed for operational personnel. Success in this area has been accomplished by using video tapes so that training can be presented at convenient times that do not cut too deeply into other operational activities.

Sufficient copies of the construction traffic control manual should be made available to operational commanders and supervisors so ready reference can be made when problems are discovered in the field. It is important that officers receiving training do not just receive that training in a classroom situation, but any personnel used for work on controlled-access facilities should receive formal "hands-on" training in traffic control. This should entail actual field training in traffic direction and control, an area that has fallen into great disuse in American law enforcement circles, which needs to be revived.

It is a particularly tedious process to direct traffic with hand signals. It is essential that it be properly done when it is required by a law enforcement officer or by anyone charged with that responsibility. It should not be taken for granted that a law enforcement officer who has received basic training will be skilled at traffic direction. If an officer does not show an aptitude for this type of training, if at all possible, he should not receive this type of assignment.

I do not want to imply that it is only the operational officer in an enforcement agency who needs to receive training in work zone safety. This kind of training should be received by upper-level management personnel, especially field commanders, and by the on-line supervisor and the field officer. It should be appropriate to the job decisions each individual is required to make. It is important during these training periods to stress the importance of the work zone, from a safety standpoint, and also from a jurisdictional liability standpoint.

A continuing problem that should be stressed in all training exercises is that officers must watch to be sure that when signs are out, actual construction is going on, and that when construction ceases and the road is returned to normal, that the construction signs are removed. This is a particularly vexing problem nationwide and one that when not followed, breeds disrespect by the motorists for construction and maintenance work zone areas.

Secretary Skinner has developed a comprehensive compendium to address the transportation issues and Federal policies to guide America into the next century. In the area of transportation safety, it is now Federal transportation policy to promote a cooperative work environment in transportation and ensure that transportation workers can depend on safety in the work place. Toward that end, cooperation with transportation companies and others in the private sector, as well as universities and other educational institutions to develop specialized programs for training programs for training transportation personnel at all levels is an important step toward creating an awareness of safety issues and procedures in highway work zones.

INSPECTION

The best planning and training programs will go for naught if adequate inspection is not done on a regular basis throughout a construction project's life. It is particularly important that the police be involved in active inspection because the patrol officer is the one government official who is on the highways during all climatic conditions, both in daylight and in dark. He is the one official who can regularly monitor the highway safety enforcement, particularly in work zones, under all conditions.

A properly trained traffic officer can see that motorists are guided in a clear and positive manner while approaching and traversing work zones. He can check to see that

adequate warning, delineation, and channelization is accomplished to assure that the motorist will have the guidance he needs in advance and throughout the work zone area.

Work sites need to be carefully monitored under varying traffic conditions, both in good and bad weather, to ensure that traffic control measures are effectively operating, that the devices are clean, and, if reflectorized, that they are working up to their design capability. If an accident problem identifies itself, a careful analysis should be made by both engineers and enforcement officials of the jurisdiction to determine the cause of the accident and to take corrective action wherever possible.

Enforcement officers should keep track of any skid marks or damaged traffic control devices that may indicate a need for a change in the traffic control design. Once again, and it needs repeating, all traffic control devices should be removed when they are no longer needed. On many high speed, high volume areas, a majority of the work must be done at night to eliminate as much traffic congestion as possible. This can make for an extremely hazardous work zone area, and it should be carefully monitored by law enforcement officers under the varying conditions previously listed. On inspecting work zone areas, enforcement officers should be alert where civilian flaggers are used to be sure that the flaggers are devoting all their attention to the job.

One practice that has been noted recently in work zones is that to counteract boredom, some flaggers have been allowed to wear Walkman-type portable radios. This is extremely hazardous, not only for motorists traversing construction zones, but also for workers in the construction zone and the flagger himself. All flaggers and officers directing traffic in a construction work zone should pay 100 percent attention to their job and not be distracted by any outside influences.

Officers are uniquely qualified by investigative and report training to bring hazards in work zone quickly to the attention of those who can take appropriate corrective action. Several years ago, the Arizona Department of Public Safety developed the following 16-point inspection guideline for field officers to use in work zone areas, and I would recommend its continued use to all enforcement officers who are so assigned.

1. Do traffic control devices conform with the Traffic Control Manual?

2. Does traffic flow smoothly and safely?

3. Are workers safely protected from traffic?

4. Are provisions for pedestrians adequate?

5. Are equipment, materials, workers, and vehicles kept away from traffic?

6. Is advance warning appropriate to work-in-progress?

7. Are design and maintenance of temporary bypass or detours adequate?

8. Is traffic protected from abrupt drop-offs?

9. Are temporary pavement markings used effectively?

10. Are old pavement strips obliterated?

11. Are traffic control devices properly positioned, in sound condition, and well maintained?

12. Are flaggers used as needed and performing well?

13. Are signs properly reflectorized and readable?

14. Are signs covered or removed when out of use?

15. Are hazards properly shielded?

16. Are there adequate signs and barricades at intersections?

Some earlier comments have been made concerning nighttime operations, and in addition to those, I would like to stress one or two more points that must, from an enforcement standpoint, be taken into consideration during nighttime operations. Inherent problems surrounding nighttime operations are poor lighting of the scene, less than optimum sign visibility, and inadequate delineation. One of the major failings in nighttime operations, which can also be found in daytime operations, but is aggravated by nighttime, is the failure of contractors to keep signs properly spaced, properly located, and clean so that they are working at their optimum ability.

An enforcement officer can bring this information to the attention of construction crews and the maintenance foreman as they view these situations while they traverse a work site. It is important for the people in the engineering discipline not to resent this kind of information when it is brought to their attention by the enforcement officers.

Another problem which is aggravated by nighttime operation is that unless carefully monitored, construction and maintenance lighting that helps facilitate the construction or maintenance effort may inadvertently blind motorists. Unless regular inspections are made of the site, this may not be readily apparent.

Also along the line of lighting, it is a given as far as enforcement officers are concerned, that by far, the most effective early warning device can be a properly located and utilized arrow board. However, one thing that should be carefully watched is that the arrow board does not itself become a hazard by having the rheostat set so high that the lights are blinding to oncoming traffic.

A design feature which needs to be closely looked at, both day and night, is the use of tapers. We think it is important for planners to err on the side of longer tappers rather than shorter tapers, as short tapers can be hazardous themselves, whereas long tapers usually can give greater opportunity for motorists to merge into the existing lanes.

One of the greatest problems we see in the use of tapers is that there is not sufficient upstream warning and signing so that motorists can voluntarily leave the highway or voluntarily begin to merge far upstream from the work zone. In some high-speed, limited- access operations, we believe that seven miles is not too far to give advanced warning of an upcoming taper to a work site.

Another consideration, which has been effectively used in many jurisdictions, is the use of uniformed officers utilizing marked police vehicles at work sites. Police administrators should insist that this be done by off-duty officers from the respective jurisdiction. All costs for both officers and equipment should be borne by the contractor and billed back to the jurisdiction.

I must hasten to point out, however, that there are some police administrators who aggressively disagree with this procedure and do not believe that off-duty officers should be used in construction sites. When this is the case, it is essential to use trained civilian flaggers and properly marked and identified vehicles.

The use of police in highly visible locations prior to and throughout work zones can yield some significant crash-reduction benefits. For example, State troopers in Indiana working on regular time but reimbursed by Indiana DOT are used only while the contractor is working. So far, officials have noticed a 16-percent decrease in the number of crashes with increased enforcement.

In Kentucky, contractors received round-the-clock police enforcement during a six-month project utilizing off-duty officers. No speed-related crashes were reported during the project's entire duration. In Maryland, Virginia, Wisconsin, and Michigan, similar experiences have yielded gratifying results.

Over the years, the Arizona Department of Public Safety has found that there needs to be some efficient way to report highway problems to the Department of Transportation. To accomplish this, we have developed what we have called the "Highway Condition Report," and we urge our officers to use this in work zones, as well as on normal stretches of State highway.

This "Highway Condition Report" is made out by a field officer or supervisor and routed quickly through a modified Department of Public Safety chain of command and then to the Department of Transportation for action. We find this is a very effective way to bring requests to the attention of our Department of Transportation. A copy of this form is included with this paper for those who might be interested in adopting it or a modified version for their jurisdiction. (See Figure 1.)

DEPARTMENT OF PUBLIC SAFETY

HIGHWAY CONDITION REPORT

ON Name or number of street or highway				MILE POST No.
AT Name of intersecting road or distance from landmark				
IN City or township		County		State
HOUR	DAY of week	DATE	MONTH	19

TRAFFIC DEVICES	ROAD CONDITIONS	DISCREPANCIES
☐ Signal-Timing	☐ Debris-Rocks	☐ Inoperative
☐ Stop Sign	☐ Holes-Rough Pavement	☐ Missing
☐ Roadway Sign____	☐ Snow-Ice	☐ Obscured-Bent
☐ Detour-Construction	☐ Water-Flooding	☐ Accident
☐ Guardrail_____Ft.	☐ Other_____	☐ Other_____
☐ Fence_____Ft.		
☐ Other_____		

REMARKS:_____

OFFICER REPORTING_____BADGE NO._____

ACTION: ☐ Immediate ☐ Regular Work Hours

RECOMMENDATION:_____

INFORMATION RELAYED TO:_____

DATE_____TIME_____

DISPATCHER_____DISTRICT_____

Distribution:

White Copy- HPB District Office
Retention: 3 Years
Pink Copy - ADOT District Office

DPS 802-03770 8/84

Figure 1 - Highway Condition Report

Human factors, particularly driver behavior, are the largest single cause of accidents on the Nation's highways. More than 47,000 people died in 1988 in motor vehicle crashes. More than 40,000 collisions occurred in work zones alone. Over 700 fatalities are expected this year in over 30,000 work zones. It is unforgivable for a system that is intended to provide service to people to be the instrument of so many deaths. We can and must do more to reduce the death toll on the Nation's streets and highways.

As the population ages, special measures will have to be taken to maintain traffic safety and address the special needs of elderly and disabled drivers. Collectively, we must promote safer designs and maintenance of highways through engineering standards and signing systems that are more sensitive to the needs and abilities of all drivers--especially the elderly.

MEDIA CONSIDERATIONS

Having worked as an airborne traffic reporter for a local "all news" format radio station, I feel strongly that broadcasting trouble spots and delays in work zones during morning and afternoon drive times can significantly impact traffic patterns. For years, KTAR Radio in Phoenix used State officers, in cooperation with the Department of Public Safety, to report trouble spots and deliver safety messages during "drive-times."

Some jurisdictions have also installed temporary FM radio broadcasting stations in a work area which is going to be in operation for a long time or involves a complicated work zone operation. It can be done a lot cheaper than one would think. Simply install a continuous broadcast FM station in the general vicinity of a construction zone, preferably upstream from the construction zone, and then prominently sign the area requesting the motorists to turn to that FM station for work zone information.

We have also discovered the benefits of alerting news outlets to highway emergencies simultaneously from a central control point. Located in the department's duty office, the "media alert" system is a direct hotline to almost all electronic and print media in Tucson and Phoenix. Outlying areas are served by AP and UPI. From this central point, field commanders call the duty officer from a cellular phone and are routed into the media alert system. As a full duplex system, the caller can be interrogated for specific information following a general announcement that in the case of radio can be transferred to the air in a matter of seconds.

Engineering and law enforcement alike should encourage further technological advancements in intelligent vehicle highway systems (IVHS), as well as developments that alert drivers to hazards or congestion, provide alternate routing information, and help motorists avoid collisions.

CONCLUSIONS

In closing, let me make three points:

1. Unfortunately, a large number of law enforcement officers and agencies are ignorant of what is involved in properly planning, inspecting, and enforcing work site control. It is up to the engineering community to help educate their local police jurisdiction in this matter, specifically, in familiarizing them with work zone manuals and bringing to their attention, what authority the police do have and what kind of problems maintenance and construction work zones can cause the motoring public and, thereby, the police agency.

2. After all of the planning and training is completed, there must always be an alternate plan for routing traffic in the event of a complete closure of one or more of the segments of highway either under maintenance or construction. To serve the motoring public properly, both the engineering agency and the enforcement agency must be flexible in their operations and planning.

3. With increase in reconstruction of much of the Nations's infrastructure, a noteworthy increase in the number of fatalities and crashes occurring in construction work zones has drawn national attention. A renewed emphasis by law enforcement and engineering is essential to reverse this alarming trend. Selective enforcement programs, improved signing, public information, and education campaigns, and alternative routes are all worthy of consideration. Our safety initiatives rest on public awareness and approval, education, sound engineering and operating practices, supplemented by effective enforcement and continuing research and analysis on the best approaches to meet safety goals. Together, we can meet the President's goal of cutting the death rate in traffic crashes to 2.2 fatalities per hundred million miles by 1992 and work to further develop an awareness and sensitivity toward highway safety nationally.

NEW CONCEPTS IN WORK ZONE TRAFFIC CONTROL

Robert M. Garrett
Executive Director
American Traffic Safety Services Association

Over the past 20 years, we have gotten better standardization of devices. We also have better enforcement of specifications, but we still have a long way to go. This is a discussion of new concepts and developments that are changing work zone traffic control. Many of these and other innovative devices will be on display at the American Traffic Safety Services Association (ATSSA) 21st Annual Convention and Traffic Expo, being held January 20-22 in Orlando, which many of you will have the opportunity to attend.

One area of concern is the safety of the driver and the worker. The best way to protect the workers in the work zone is to separate them completely from the driving public. In the past 20 years, concrete barrier walls have been developed and are used extensively. One problem with the heavy barrier walls has been transporting them. One new development (marketed by Barrier Systems of California) is a transfer vehicle which easily moves concrete barriers from one lane to another. The vehicle moves at approximately 5 mi/h which will move approximately 1 mi of concrete barrier in 20 minutes. The T-section end of the concrete barrier section links with another end to form a chain. The barrier wall sections are lifted by the transfer vehicle and moved from one lane to the next like a chain.

A concrete barrier can also present a hazard, especially the blunt ends of the walls. Three types of attenuators devices have been used to protect the end of the barrier. One type is sand-filled barrels. Previously these barrels were filled with water; a few water-filled barrels are used today. A more permanent type of attenuator is the G-R-E-A-T™ absorption system, which consists of crashable cartridges surrounded by guardrail. The system absorbs the energy of the crash and protects the driver. If hit on the side, the G-R-E-A-T™ system redirects the vehicle back onto the travel way. Truck-mounted attenuators are also being used more extensively to protect the driver from the end of the concrete barrier. Cells are filled with polyurethane foam, which absorbs the energy of the crash when a vehicle hits the attenuator.

Another way to separate the worker from the driver is a plastic barrier wall developed in Europe. This barrier section is used as a delineator device and is usually filled with water or sand. When filled with sand or water, each section weighs approximately 33 lb, which is less than a concrete section. A fence (from Plastic Safety Systems), which does not replace a barrier, is used for visibility. The fence has highly reflective tape on the rails, which give good visibility at night.

Another new barrier system from England is a drum-type system that nests together. This is not, however, a positive barrier against a vehicle. A drawback is that a solid wall of the drums is expensive. Another problem is that if one drum is knocked down, the rest tumble like dominoes.

One of the most dangerous jobs on a work site is putting out cones and retrieving them. This work cannot be done within a barrier wall, and, therefore, new devices, such as cone wheels that provide safe placement and retrieval of cones, are much needed. A cone wheel (from AADCO Manufacturing) automatically places and spaces cones and retrieves them when the job is finished.

If a worker cannot be placed behind a barrier wall or away from traffic, he or she must be made more visible. A reflective vest is the most commonly used device. Some Europeans and Canadians wear complete uniforms with reflective strips, which makes the wearer highly visible to oncoming traffic. Many jurisdictions mandate the use of reflective uniforms for firemen, but not for construction workers yet.

Besides separating the worker from the drivers, another new concept in work zone traffic control is "forgiving" devices. Historically barricades have been made of angle-iron legs and plywood boards. These have been effective and recognizable, however, when struck, the barricade harmed the vehicle, and the flying debris harmed workers nearby. One new concept is an all-plastic barricade (from Best Barricade of Chicago), but these are expensive.

Channelizers or plastic drums have been used frequently. At first, there were problems when the drums were struck and the battery for the flashing light flew off and become a missile. Now there are better attachments between the battery and drum, and a flying battery is not as much of a problem.

Another new alternative (from Flasher Handling of Buffalo, New York) is a 36-in x 12-in vertical panel, which is attached to a vertical shaft. The flashing lens is attached to the top of the shaft, and a wire, attached to the lens, runs down the shaft to the battery at the base, which also weighs down the stand.

One type of barricade used in Europe (and now distributed by WLI Industries of Chicago) is an all-plastic barricade with the battery attached to the bottom. The barricade is hinged on the bottom; therefore, when struck, the barricade's striped panel bends over, and the vehicle drives over the barricade instead of through it.

One area of concern in work zone traffic control is energy conservation. Solar-powered control boards are beginning to be used with solar panels either on the bottom or the top. In the next few years there will not be as many diesel-powered arrow boards. Technology has advanced so that solar power can be used effectively in States other than Arizona and Florida. Solar-powered portable sign trailers (distributed by Renco, Inc.) are also beginning to be used.

Portable signals have been around for a while, yet recently this control device has been improved. The portable signals now meet Part VI of the Manual on Uniform Traffic Control Devices. They can be equipped with dual heads and can use diesel power and AC power. They can also operate with loops or timed signals.

Pavement makers have also had new developments for work zone traffic control. One such development (from Davidson Plastics) is a temporary marker for chip and seal operations. These markers can be placed down and then can be chipped and sealed over. A slip cover is removed from the marker, which provides delineation after the completion of the chip and seal operation.

There still are many problems in work zone traffic control. No matter how much has been developed technologically, there is still the problem of educating the public, the worker, and the contractor. There are good standards, but if they are not enforced and if contractors aren't forced to use standard devices, there cannot be a safe, effective work zone. All the technology in the world will not get the contractor to put out standard devices, unless there is good enforcement.

WARRANTS AND PROPER DEPLOYMENT OF FLASHING ARROW PANELS

Joseph J. Lasek, P.E.
Chief, Technical Development Branch
Federal Highway Administration

Borrowing from the old cliche, "It's the greatest thing since sliced bread," the flashing arrow panel was the sliced bread of work zone traffic control devices when it was introduced in work zones in the early 1970's. It had an immediate impact on managing traffic flow through work zones.

It is easy to understand why it had such an impact because the arrow panel has all the desirable features of a good traffic control device. It has great conspicuity (bright flashing lights), early recognition (good long-distance visibility), and easy message understanding (simple design conveys single message).

However, as good as the basic device is, there have been and continue to be some problems in its use. Some of the early problems were a lack of uniformity in the design of the arrow panels and an attempt to use them for all types of work zone situations. Other problems, then and now, are poor location of the arrow panel, inadequate sight distance being provided, and improper application.

BACKGROUND

One of the early efforts to establish objective national criteria for arrow panel placement and operation in work zones was a Federal Highway Administration (FHWA) sponsored research project. A final report on the research was published in early 1979 and was titled, "Guidelines for the Application of Arrow Boards in Work Zones." The report findings were significant and influenced subsequent national guidance. Some of the key findings were:

- Arrow panels were effective in lane closure work zones because they promoted earlier merging into the open lane.
- The arrow panel was more effective when it was placed on the shoulder of the roadway near the start of the lane closure taper.
- Arrow panels were not found to be generally effective in traffic diversions, traffic splits, or for moving shoulder closures.
- The flashing arrow is the most effective mode for conveying its message.

The sequential-chevron mode is also effective and generally superior to the sequential-arrow or sequential-stem modes.

As a result of this research and other individual State research projects, guidance on the design and use of flashing arrow panels was initially included in the FHWA's 1983 Traffic Control Devices Handbook (TCDH). The TCDH is a guide only and does not establish FHWA policies or standards.

Subsequently, much of the same information was approved as standards for arrow panels and was added as a revision in March 1986 to the 1978 Manual on Uniform Traffic Control Devices (MUTCD). The same standards and application information was included in the 1988 revised MUTCD.

A key point that the 1988 MUTCD makes, which is sometimes overlooked by work zone traffic control plan designers, is that the arrow panel is intended to supplement other standard traffic control devices. It will not solve difficult traffic operational problems by itself.

Before continuing, the reader is reminded that Part VI of the MUTCD dealing with traffic controls for street and highway construction, maintenance, and utility operations is in the rulemaking process for revisions. Some of the proposed changes involve the application of arrow panels. The remainder of this presentation will focus on the MUTCD design requirements and applicable uses for arrow panels including proposed additions and proposed revisions. Unfortunately, it is too early in the rulemaking process to identify what the final changes will be.

ARROW PANEL DESIGN REQUIREMENTS

Minimum legibility distance requirements will continue to be specified in the MUTCD as shown in Table 1. There will also be narrative to provide guidance as to each panel type's applicability for use.

Table 1. Minimum Legibility Distance

Panel Type	Minimum Size (In)	Min. Legibility Distance (Mi)	Min. Number of Elements
A	48 by 24	1/2	12
B	60 by 30	3/4	13
C	96 by 48	1	15

Note the use of elements in lieu of lamps in Table 1. Because some manufacturers are producing arrow panels using flipping disk technology, it is necessary to avoid specifying lamps only.

Besides physical size, arrow panels should have the following physical attributes:

- An arrow panel shall be rectangular, of solid construction, and finished with nonreflective flat black. The panel shall be mounted on a vehicle, trailer, or other suitable support. Remote controls should be provided for the panel if vehicle mounted.

- The minimum mounting height should be 7 ft from the roadway to the bottom of the panel, except vehicle-mounted panels should be as high as practical.

As with other signs, the 7-ft minimum height is to achieve maximum visibility, even over vehicles driving ahead of you.

Although minimum size and mounting height are specified to achieve legibility distances, it is equally important for work site personnel to exercise care in the vertical and horizontal alignment of the arrow panel and its location along the roadway to assure that the maximum effectiveness of the arrow panel is obtained. The goal is to make the panel visible from as far away as possible and keep its visibility as the driver approaches the work area.

Operational design requirements of arrow panels remain essentially the same as identified in the current MUTCD with some slight exception. The panel elements are to present yellow color, and the arrow flashing rate shall not be less than 25 or more than 40 flashes per minute. Also, the minimum "on time" of the lamps shall be 50 percent for the flashing arrow mode and 25 percent for the sequential chevron mode. These minimums provide the best recognition factor. A very important requirement is all types of arrow panels must be capable of at least 50 percent dimming from their rated lamp voltage when lamps are used in the panel. Full voltage is needed for daytime visibility and reduced voltage for nighttime use to reduce glare.

Unfortunately, the dimming of panels at night is often neglected. The bright light and glare produces temporary loss of night vision, often at the critical point where the driver is entering the actual work zone and clearances may be reduced. Although some arrow panels may have manual dimming controls, it's clearly better to have the dimmer operated by a photocell. The lamps are automatically dimmed appropriately as the photocell system senses the reduced ambient light. This overcomes forgetting to dim manually the arrow panel each night.

Finally, the arrow panel should have the following selections of operating mode:

- Left or right flashing arrow, or

- Left or right sequential-arrow, or
- Left or right sequential-chevron,
- Double flashing arrows, and
- Caution mode.

These modes are shown in Figure 1.

It should be noted that the design for the caution mode is being proposed for four elements only, with one in each corner of the panel. Currently, the arrow stem without the arrow head is considered an acceptable pattern for the caution mode. The four corner pattern is more definite as to intent. The stem pattern is sometimes interpreted as a malfunctioning arrow, and unnecessary lane changing may occur.

Also, it should be noted the L or R sequential arrow mode consists of several arrowheads that flash in a series directing traffic to the right or left. Some manufacturers' arrow panels use a sequential arrow that consists of elongating the stem with the arrowhead only being illuminated on the last part of the series. That is not a correct sequential arrow.

POWER SOURCES

Relative to the arrow panel equipment, there are about 13 manufacturers producing arrow panels. It appears most, if not all, are in good compliance with the MUTCD minimum design requirements. However, one item the MUTCD does not have any standards for is the power supply for the arrow panels. Available power supplies include diesel, gasoline, solar, and batteries. Diesel generators are the most commonly used power supply, and many of the manufacturers provide the various power sources as alternatives. Most of the State transportation agencies have specifications requiring self-contained power supplies that are capable of running arrow panels for a designated length of time, such as 72 hours.

Because arrow panels are exposed to traffic, collisions are possible. Because diesel fuel or batteries present a lesser fire hazard than gasoline in an accident, gasoline-powered generators should be avoided whenever possible.

There are a limited number of companies currently producing solar-powered arrow panels, but their use is becoming more widespread. Solar collectors mounted on the trailer charge batteries that power the panel lamps. However, there should be enough batteries to power the lamp during periods when little sunlight can be collected. It is important to position the collection panels to catch the maximum amount of sunlight, but

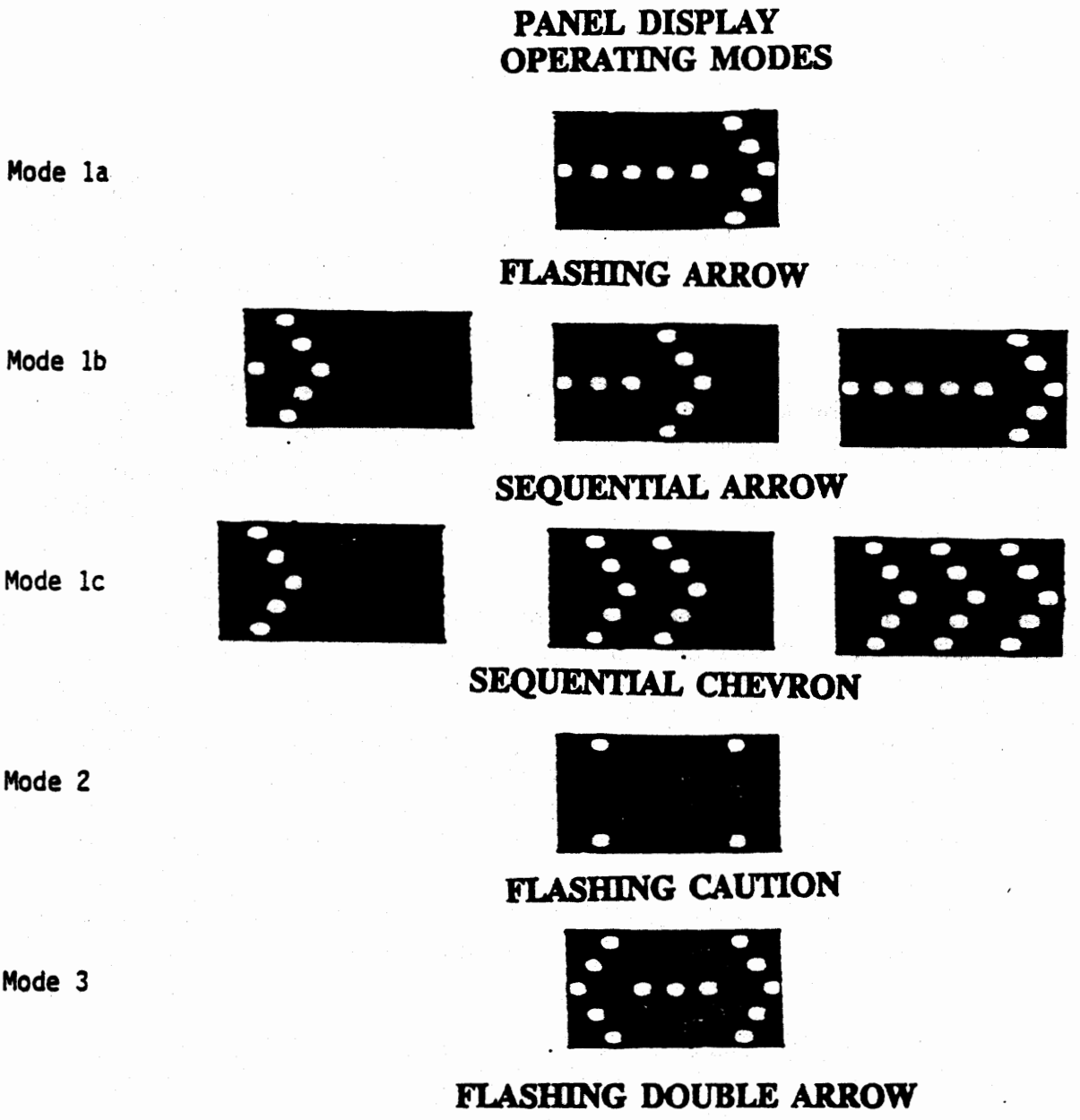


Figure 1 - Flashing arrow panel operating modes.

not to the detriment of aligning the arrow panel for maximum visibility. Fully charged batteries can run an arrow panel for weeks, depending on ambient temperature.

Vehicle-mounted panels are usually designed to run off the vehicle's battery system and do not require their own power supply.

ARROW PANEL APPLICATION

Next, let's look at the desirable applications and placement of arrow panels. As identified by the research previously mentioned, lane closures are the single most suitable application. The arrow panel, when in an arrow mode, conveys to the driver the overriding message "lane closed ahead." Supporting that message, a revision in the wording of the MUTCD is being proposed. It will require that arrow panels displaying the arrow or chevron mode will be used only for stationary or moving lane closures.

A critical exception to use of arrow panels for lane closures, however, is on a two-lane, two-way road. Obviously, if you use an arrow panel to close one lane on a two-lane roadway, there is the risk of guiding drivers into the path of oncoming traffic. For this situation, the use of flag persons or portable traffic signals is necessary to safely alternate the traffic flow on the remaining single lane. Arrow panels are primarily suited for use on multilane roadways!

Given that the most effective use for an arrow panel is for a closed-lane situation on a multilane roadway, the best location to place the arrow panel is at the beginning of the taper of the channelizing devices--on the shoulder. This assumes sufficient width of the shoulder. If a narrow shoulder or no-shoulder condition exits, then the next best location is behind the taper of channelizing devices in the closed lane, but as near the start of the taper as possible. The objective is to maintain a good line of sight, but to keep the panel from becoming a hazard to the motorists.

Figure 2 shows the most typical application of arrow panels on a frequently used traffic control setup. The right or outside shoulder lane is closed, and the work zone is protected by traffic barriers. This would be applicable for a longer duration work zone. Please note the use of channelizing devices to establish the taper of L length, in lieu of using the barrier to establish the taper. It has sometimes been the practice to use temporary concrete barriers with delineation to develop the taper. Invariably, the downstream barrier where the taper ends and the tangent section protecting the work zone begins is heavily covered with tire marks. The frequent striking of it indicates the problem drivers have with the visibility of this point.

If this was a short duration work site and no barrier was provided, the emphasis would be to use a shadow vehicle to protect the work site and use a vehicle-mounted arrow panel at that location.

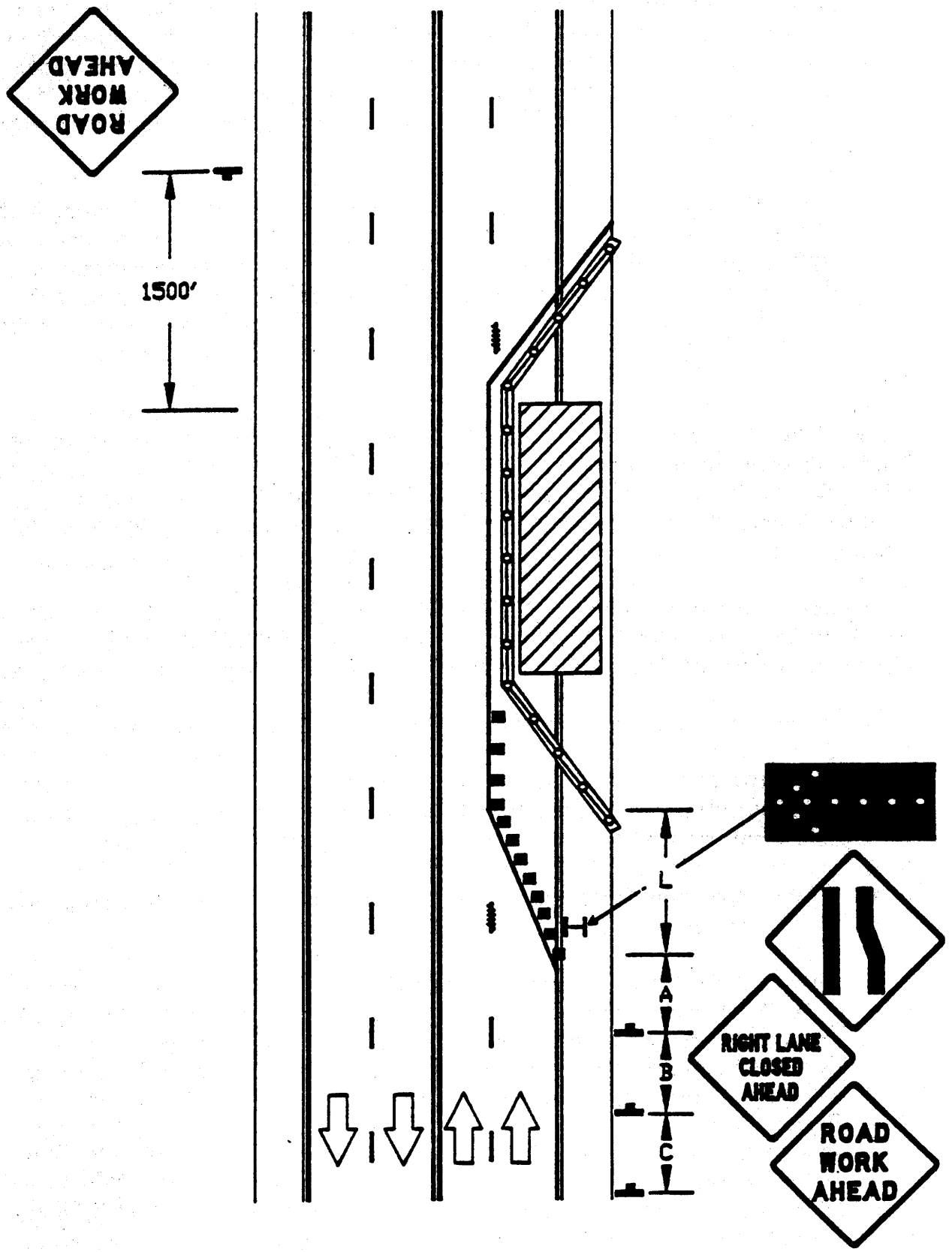


Figure 2 - Outside lane closure with barrier.

Figure 3 shows a typical traffic control plan for a left lane closed on an undivided four-lane facility. An adjacent lane is closed to provide access and working space. Under this situation, a shoulder is not available and the arrow panel must be located behind the channelizing taper near its beginning. The arrow panels for both directions are aligned with the closed-lane traffic, and the message to vacate that lane is clearly given.

The next application shown in Figure 4 involves closing two lanes of three or more directional lanes. The two right lane closures require initial closing of the outside lane with a standard L length taper. Then traffic is allowed to normalize over 2L length with channelizing devices keeping the right lane closed. A second taper of L length is used to close off the second lane. The first closure is achieved using an arrow panel and its standard location. Note the second lane closure in this example is achieved by using a vehicle-mounted arrow panel, with the vehicle located to protect the work zone. Currently, this is an "optional" arrow panel.

Proposed revision to the MUTCD (Part VI) will require an arrow panel to be located in each additional closed lane after the first lane closure. In this example, a 2-second arrow panel would be located in the second closed lane behind the taper of channelizing devices. Preferably, it should be near the start of the taper.

The next application, Figure 5, shows a traffic control plan for the most difficult lane closure situation to handle from a safety viewpoint. That is the center lane closure for a three-directional lane facility. A number of traffic control variations have been tried through the years to identify a best solution for this problem. As of late 1988, the FHWA instructed their field offices to use a single right arrow panel to close the left (median) lane and eliminate the double flashing arrow panel located in the middle closed lane.

The current proposal is to use both arrow panels, and the second arrow panel is the key one. There is a difference of opinion among highway engineers on this matter because of possible confusion caused by seeing two flashing arrows or chevrons pointing in the opposite direction. This can be the case for curving road alignment and foreshortening due to vertical grades. At this point in time, this is an unsettled issue.

Note the first arrow is for the lane closure, while the second arrow is giving the message "traffic splits." It does reinforce the message of the standard warning "double arrow" sign located at the nose of the split. A more descriptive informational sign using a symbolic warning sign showing the left lane shifting left and the right lane continuing through is being considered. If accepted, it would replace the "center lane closed ahead" sign.

If the flashing double arrow panel is adopted for use in this situation, it should be fully centered in the closed lane behind the tapered channelizing devices. This means the arrow panel would be at least three-quarters of way downstream from the start of the left-shift taper. See Figure 6.

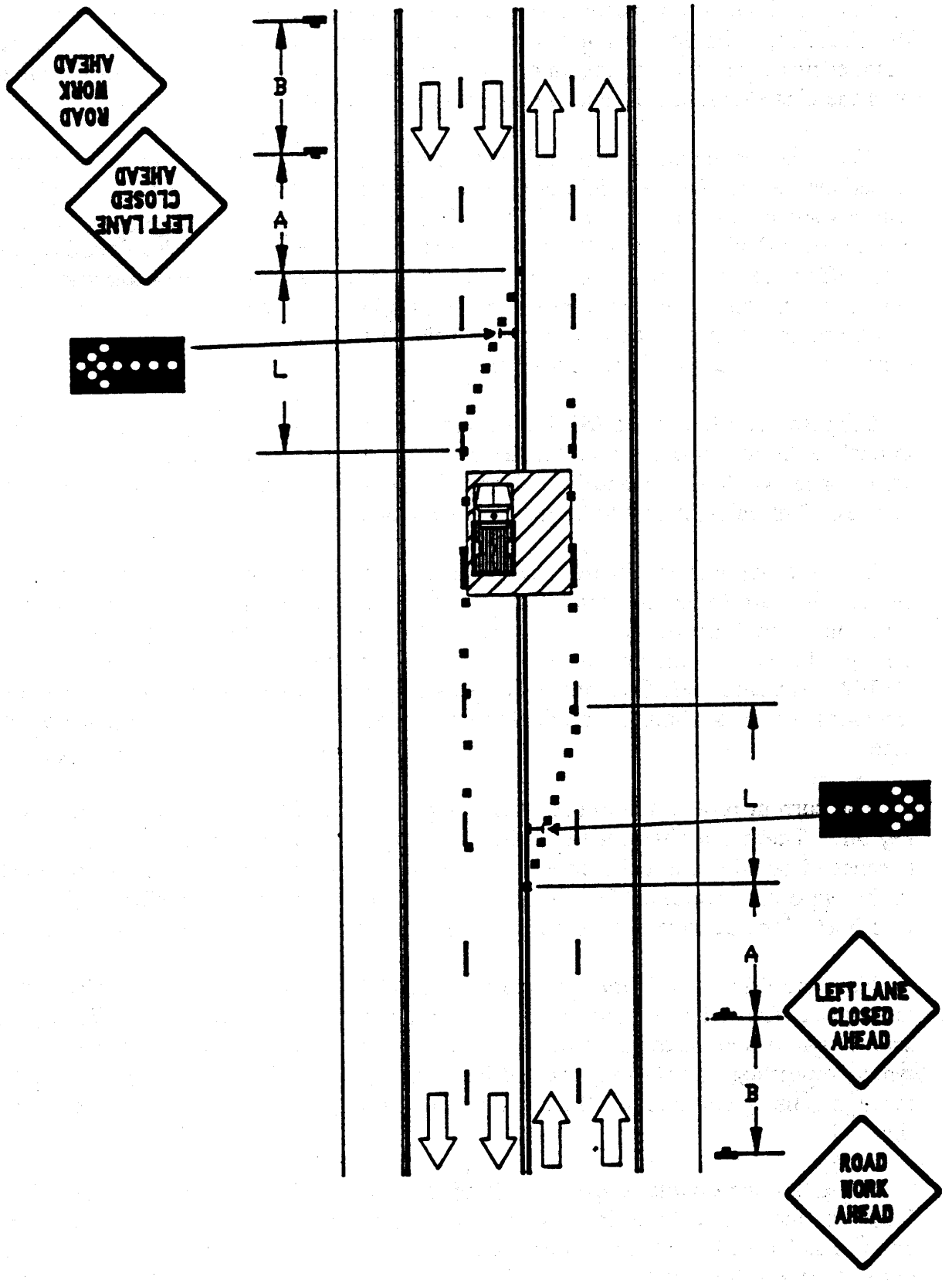


Figure 3 - Work within left lane with access from adjacent lane.

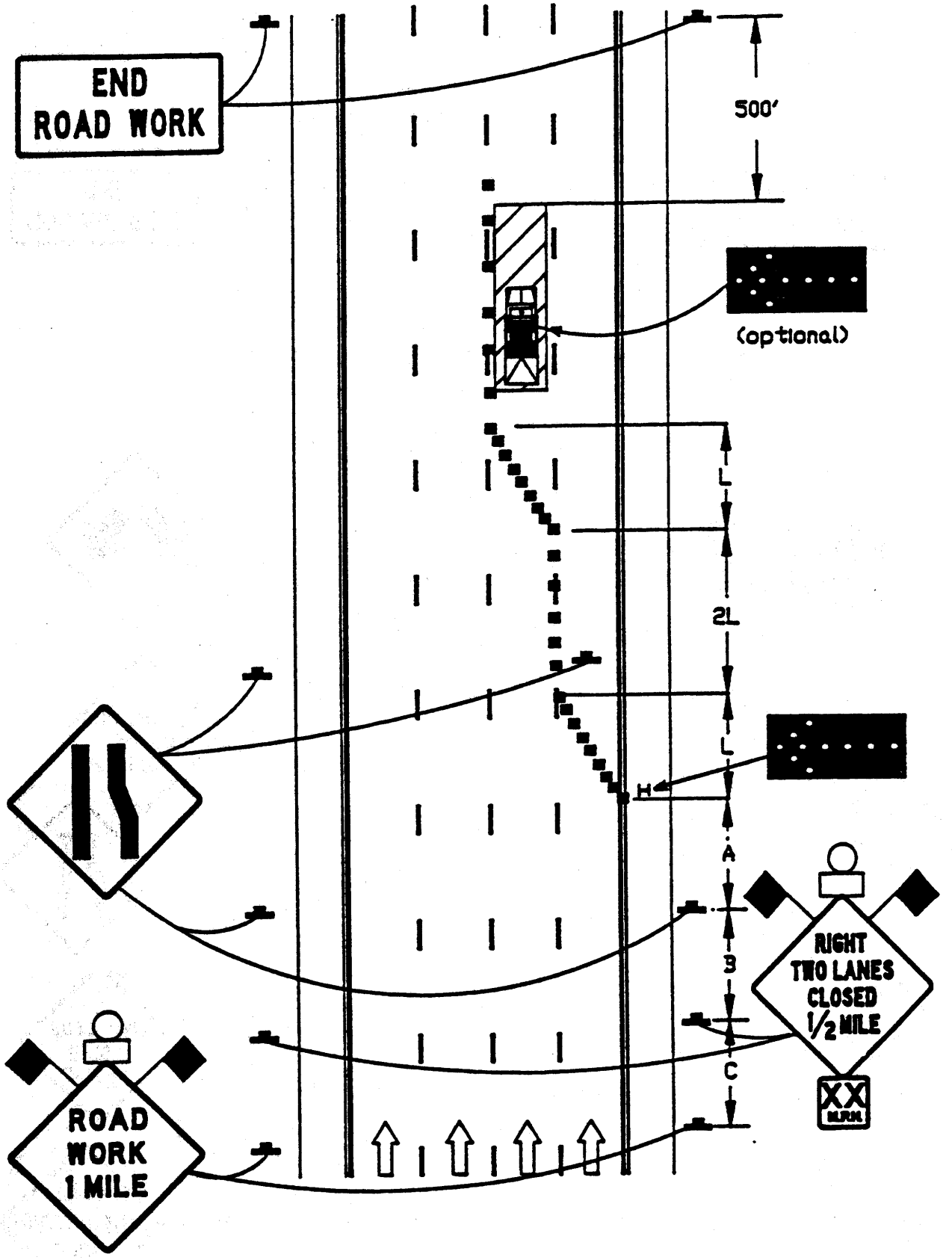


Figure 4 - Multiple lane closure.

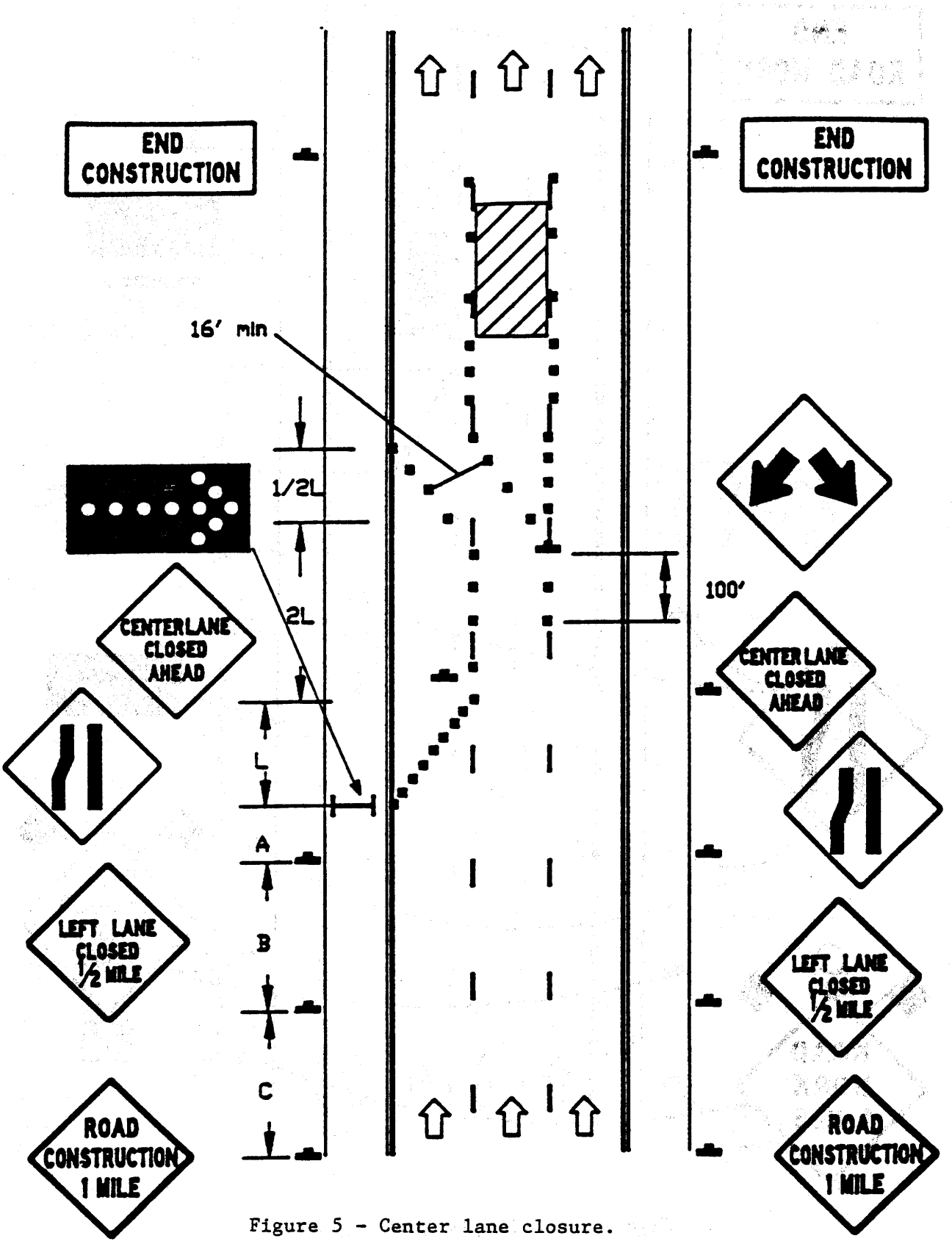


Figure 5 - Center lane closure.

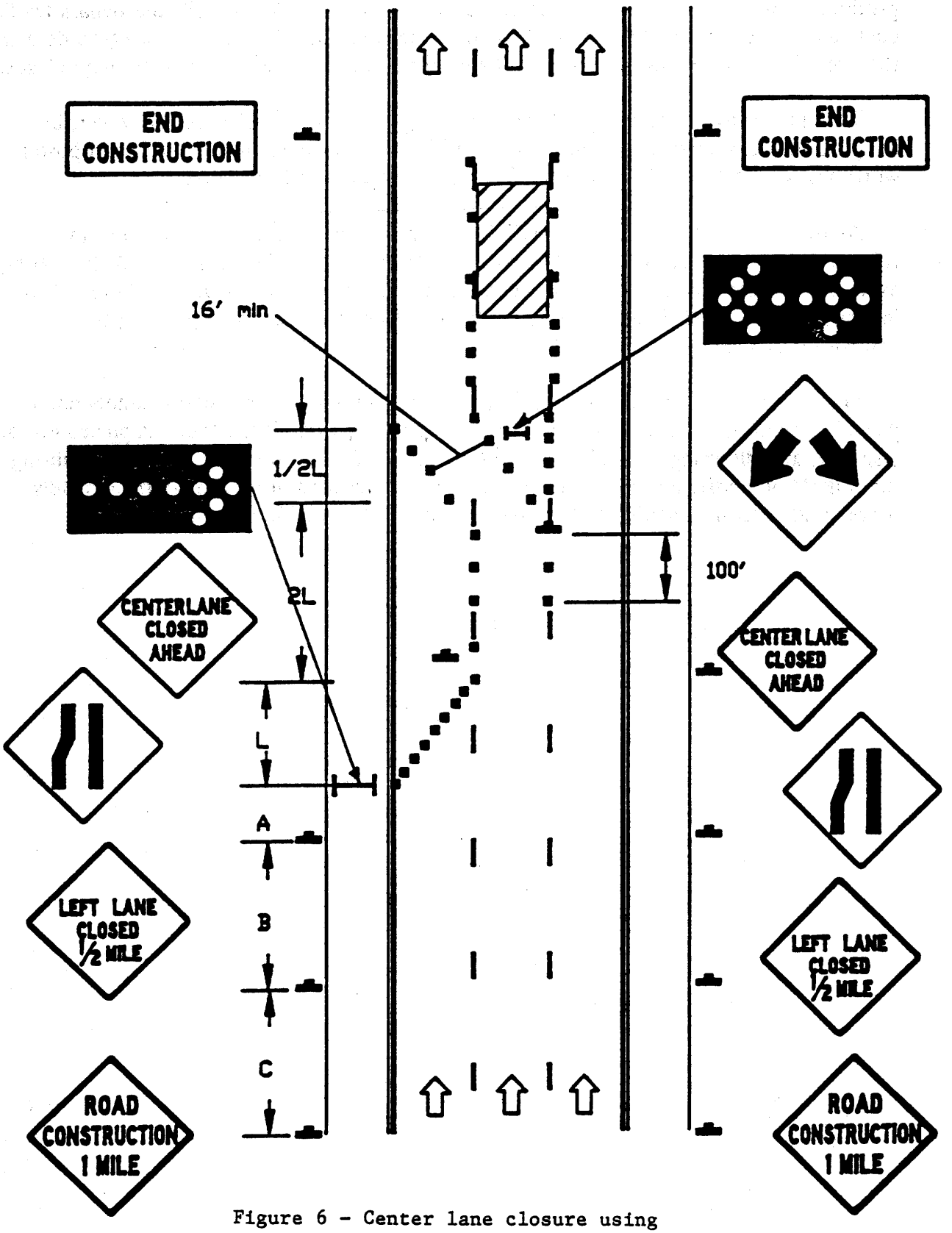


Figure 6 - Center lane closure using double arrow panel

The final typical application involves the work zone bypass creating a two-lane, two-way operation on a normally four-lane divided facility. See Figure 7. This situation also produces some disagreement on the use of a third arrow panel to shift the bypass traffic back across the median to its original side of the roadway. There is no disagreement in the use of the two arrow panels (one for each direction) for developing the lane closures.

The third arrow is currently allowed as an option in the MUTCD. However, in keeping with the concept that arrows should be used for lane closures only, proposed word changes in Part VI would prohibit the use of the third arrow panel.

As the revised Part VI of the MUTCD goes through its final deliberations and rulemaking, there may be further changes made in the material presented in this paper, especially concerning arrow panel applications. Therefore, the reader is cautioned to stay informed of the official changes to Part VI as they occur and revise pending traffic control plans accordingly.

Like any other traffic control device, especially in work zones, arrow panels need periodic attention. Generators need oil changes, lamps and lenses need replacement and cleaning, and dimming controls need to be checked for malfunctions, etc. Considering the impact on traffic by arrow panels and the cost invested in installing arrow panels, there is no reason to settle for less than 100 percent effectiveness when in use.

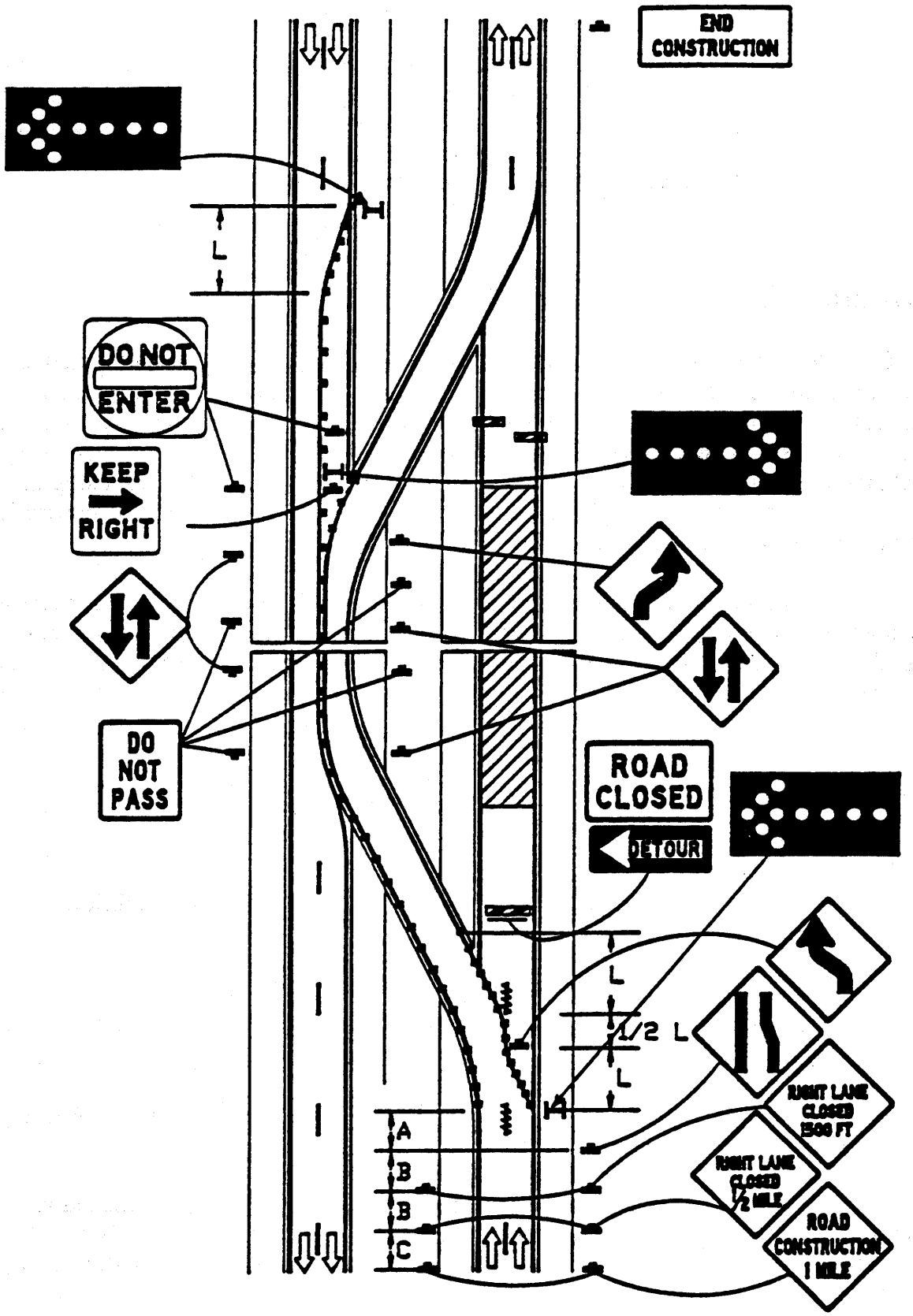


Figure 7 - Bypass two-lane two-way operation.

CURRENT PRACTICES IN THE USE OF STEADY-BURN WARNING LIGHTS

Gerhart F. King, P.E.
Manager, Transportation & Safety Engineering Projects
KLD Associates, Inc.

INTRODUCTION

It has long been recognized that enhancement of the visibility and conspicuity of traffic control devices is one of the most effective tools available to the engineer. Given the absence of fixed ambient lighting at many locations where work on, or adjacent to, the travelled way is necessary, it was recognized early that one method of increasing both visibility and conspicuity was the installation of small, self-contained illuminating units in conjunction with individual traffic control devices, including signs as well as barricades and other channelization devices.

In the beginning, open flame torches, using liquid fuel, were used for this purpose. Recognition of the hazard and maintenance problems associated with such devices, together with advances in battery technology, soon led to the replacement of open flame devices by battery-powered warning lights. In recent years, however, a trend opposed to the use of these lights has developed for a number of reasons. These reasons include:

- A high incidence of theft and vandalism of warning lights.
- The high cost, both labor and material, of regular battery replacement.
- The fear that these devices might act as projectiles in case of a collision.
- The introduction of much brighter retroreflective materials.
- The replacement, in many cases, of cones and barricades with barrels or drums with a much larger exposed area.
- The increased use of high impact advanced warning devices, including flashing arrow boards.

On the other hand the increased involvement of older drivers, with reduced visual and sometimes cognitive facilities in the traffic stream has increased the need for highly conspicuous and visible work zone traffic control. Furthermore, the shift from new construction to the reconstruction and maintenance of the existing highway system has greatly increased the frequency with which such devices must be deployed.

In order to resolve this controversy and in order to define the proper role of Type C steady-burn warning lights in work zone traffic control, including maintenance requirements, the American Traffic Safety Association (ATSSA) is sponsoring a multifaceted study of all aspects of the use of these devices. The study is designed to complement the existing state of the art so as to:

- Delineate the comparative advantages and disadvantages of steady-burn warning lights and of competing delineation enhancement devices.

- Establish guidelines for the use and operation of steady-burn warning lights.

The present paper reports on one portion of this study: the salient aspects of a survey designed to define current usage patterns of steady-burn warning lights and problems associated with the use of these devices.

PREPARATION AND DISTRIBUTION OF THE SURVEY INSTRUMENT

The basic survey instrument was designed to elicit information from public agencies in the United States. A slightly modified version of this survey instrument, deleting references to specific sections of the US MUTCD, was used for Canadian agencies. A third version of the survey instrument was distributed to a sample of ATSSA members engaged in the rental, installation, and maintenance of warning lights. The survey forms were distributed to State, county, and city highway engineering organizations; to toll agencies; and to traffic control contractors.

The distribution of the survey forms, as well as the number of replies received in each category, is shown in Table 1. An intensive follow-up effort, using both mail and telephone, concentrated on those US states which had not responded to the original mailing.

Canadian replies indicated general nonuse of these devices in Canada. Replies from cities, counties, toll, and other agencies were too scattered to allow for meaningful analysis. The remainder of this paper will, therefore, concentrate on US practices as reported by State highway agencies and traffic control contractors.

USE OF TYPE C WARNING LIGHTS

Use of Type C warning lights in highway work zones falls into one of four distinct patterns as follows:

(1) States which <u>generally use</u> these devices in work zones.

Table 1. Distribution of Survey Forms

	No. Mailed Out	No. Returned	Pct. Returned
UNITED STATES			
States	52	47	90.4
Cities	25	8	32.0
Counties	25	3	12.0
Toll Facilities	48	16	33.3
Other	3	0	0.0
Sub-Total:			
US Public Agencies	153	74	48.4
Industry	60	33	55.0
Sub-Total: US	213	107	50.2
CANADA			
Provinces & Territories	11	4	36.4
Cities	15	7	46.7
Toll Facilities	4	0	0.0
Sub-Total: Canada	30	11	36.7
TOTAL	243	118	48.6

(2) States which sometimes use these devices, but only for defined geometric, traffic, environmental, or work zone conditions or states which leave the use or nonuse of these devices up to the individual district or division offices or states in which the use or nonuse is determined on a project specific basis by the design engineer, the resident engineer, or the performing contractor.

(3) States which rarely use Type C warning lights or States in which these devices are not used by the State highway agency but are used by major political subdivisions.

(4) States in which these devices are not used.

Figure 1 is an outline map of the United States showing this usage pattern based on survey responses received from State highway agencies. Using Federal Highway Administration (FHWA) data on highway extend and usage, totals for each usage patterns can be computed as follows:

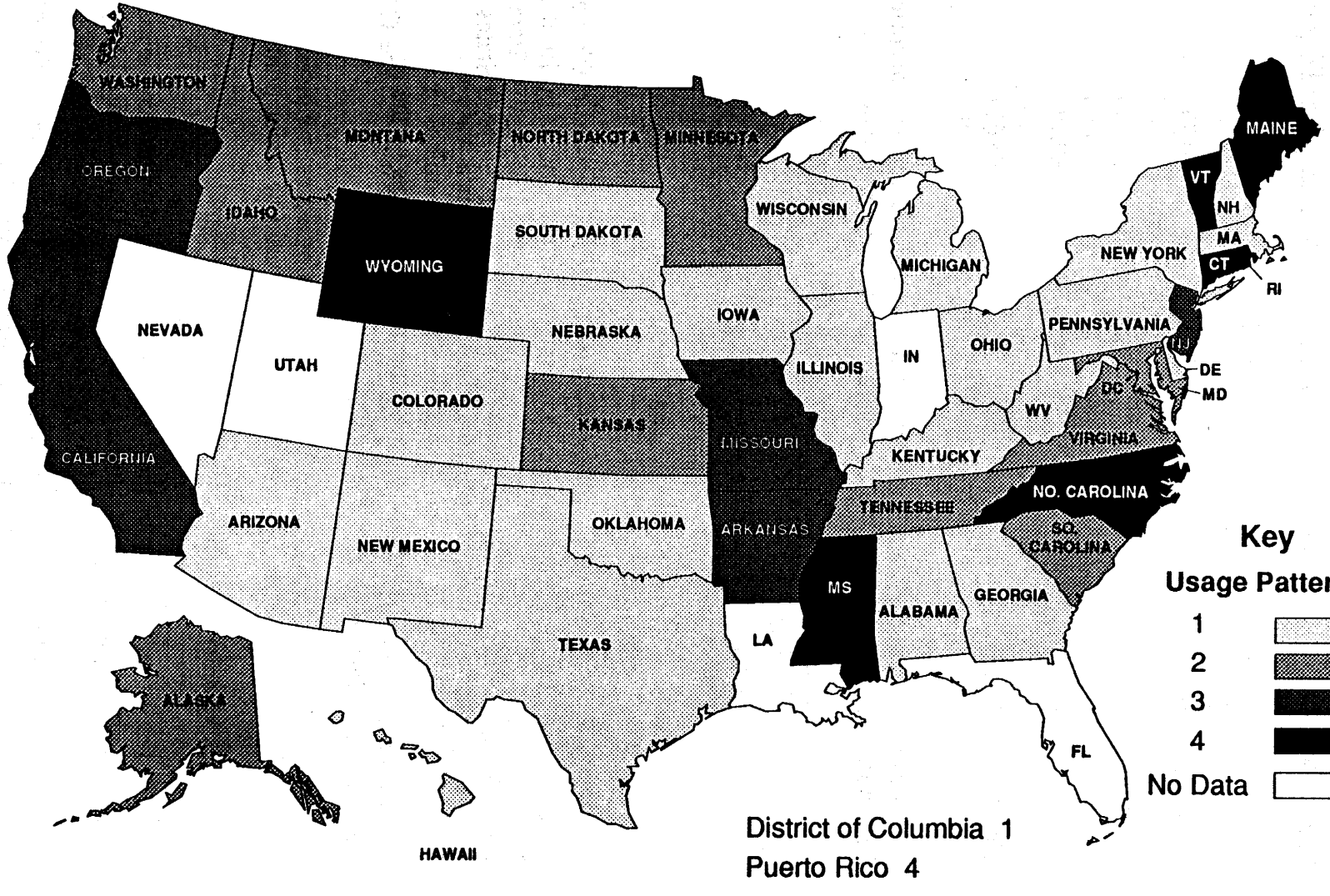


Figure 1: Usage Patterns - Type C Warning Lights - State Data

Usage Pattern		States	Arterial Miles	Arterial VMT ($x10^6$)
1	No.	23	92,659	488,661
	Pct.	44.2	50.2	46.9
2	No.	11	34,957	150,799
	Pct.	21.2	18.9	14.5
3	No.	5	26,753	239,305
	Pct.	9.6	14.5	23.0
4	No.	8	14,299	69,102
	Pct.	15.9	7.7	6.4
No Data	No.	5	15,838	96,614
	Pct.	9.6	8.6	9.3

Insofar as the five states which did not reply to the survey are concerned, information furnished by local traffic control contractors indicate the following:

State	Usage Pattern
Florida	1
Indiana	No Data
Louisiana	1
Nevada	2
Utah	1

The distribution of usage patterns, by both Census Regions and Divisions indicates some geographical diversity. Usage patterns 1 or 2 are reported by 10 of 11 Midwestern States (91%), 14 of 17 Southern States (82%) and 10 of 13 Western States (77%) but only by 4 of 9 Eastern States (44%). Four of the six New England States report never using Type C lights.

Jurisdictions in categories 2 and 3 generally restrict the use of Type C lights to one or more of the following specific conditions:

- Taper sections.
- Lane closures.
- Curved alignment.
- Shoulder drop-offs.
- Locations where the channelization device (e.g., barricade or drum) does not lie in the normal headlight beam of an approaching vehicle.

A number of jurisdictions have no fixed criteria for the use of Type C lights but leave the decision to the district or regional engineer on a project specific basis. In some instances, construction plans and specifications leave the use of Type C lights up to the contractors.

Question 2 of the survey inquired about the type of channelization device with which Type C lights are used. Responses to this question are summarized below for those jurisdictions reporting usage patterns 1 or 2.

Channelization Device		No. of States Using	Not Using	No Response
Barricades	No.	30	4	4
	Pct.	78.9	10.5	10.5
Drums	No.	31	3	4
	Pct.	81.6	7.9	10.5
Cones	No.	0	32	6
	Pct.	0.0	84.2	15.8
Vertical Panels	No.	17	16	5
	Pct.	44.7	42.1	13.2
Portable Barriers	No.	20	13	5
	Pct.	52.6	34.2	13.2

It is easy to see that Type C lights are more likely to be used with barricades or drums than with vertical panels or portable barriers. It is also interesting to note that no jurisdiction reported using the lights with cones, even though adapters for such use are commercially available. It should be pointed out, however, that a response of "no use" or "no response" could indicate that either Type C lights were not used with a specific channelization device or that the specific channelization device was not used by the jurisdiction reporting. Only a very small number of jurisdictions explicitly reported on the nonuse of specific channelization devices.

OPERATIONS AND MAINTENANCE

Because warning lights are subject to accidental damage, theft, vandalism, and battery and bulb failure, frequent inspection of these devices followed by replacement or repair, as needed, is a prerequisite for the safe and efficient operation of highway work zones. Responses to a question on inspection and maintenance intervals yielded the following responses for the 34 jurisdictions with usage patterns 1 or 2.

- Thirteen jurisdictions specifically require daily inspection.
- Fourteen jurisdictions require "periodic" or "as needed" inspection or leave the inspection interval up to the discretion of the resident engineer.
- Two jurisdictions have no specified inspection or maintenance requirement.
- Two jurisdictions require weekly inspections.
- Two jurisdictions specify inspection intervals of more than one week. One of these requires weekly inspections for "urban, high volume" roads.
- One jurisdiction requires that 3000 ft-visibility be maintained but specifies no inspection or maintenance interval.

These requirements may be explicitly stated on the plans or in project special provisions, or they may be referred to implicitly as part of the State's general specification or MUTCD. A companion question concerning contractor's adherence to these requirements yielded the following responses from those states which reported usage patterns 1 or 2:

Response	States
Meet requirements	13
Mostly meet requirements	7
Sometimes meet requirements	1
Varies	1
Very often do not meet requirements	5
Do not meet requirements	4
No response	3

A number of States reported better adherence to inspection and maintenance requirements by specialized traffic control subcontractors than by general contractors who do their own traffic control work. The discrepancy between requirements and actual practice may be due, at least partially, to ignorance or misinterpretation of applicable requirements by the installing contractors. Table 2 contrasts State requirements for inspection and maintenance, as taken from State responses, with the interpretation of these requirements by ATSSA member engaged in work zone traffic control for 21 States for which both types of data are available.

In nearly every instance, Type C warning lights are furnished and maintained by the contractor and paid for on a per light, per day, or per month basis. In some cases, especially when the use of these devices is at the contractor's option, no separate payment is made, and the cost is absorbed in a lump sum item for traffic control.

Table 2. Inspection and Maintenance Requirements

State	State Requirement	Contractor's Interpretation
Alaska	Daily	At least daily
Arizona	Periodically	Once a week
Colorado	Daily	No policy--up to resident engineer
Delaware	25-30 day interval	No policy
Georgia	Regular inspections-- Replacement with 5-10% outages	Maintain to be visible at 3000 ft
Hawaii	Daily	Keep in working order
Idaho	As directed by the engineer	No definite requirement
Illinois	To be repaired within 12 hours after notification by engineer	Service after notification - No time requirements
Iowa	Inspect daily, repair as needed	Serviced and inspected on a two-week basis
Maryland	Maintained as needed.	90% working. Must maintain 3000-ft visibility.
	"Try" to inspect daily	10% out not in series
Massachusetts	2 weeks	Discretion of resident engineer. No formal procedure
Michigan	Weekly	Weekly
Minnesota	Daily	Daily
Nebraska	As needed	Weekly
Ohio	As necessary	No specific requirement-- Up to inspector
Oklahoma	Visible at 3000 ft	Daily inspection
Pennsylvania	At least once a day	(1) No state policy, company policy is weekly check (2) Every two weeks
South Dakota	Daily	When they don't work anymore
Texas	Monthly. Weekly for urban, high volume roads	No formal inspection procedure
Virginia	Periodically	No requirements. Lights must work or not be paid.
Wisconsin	Daily	Lights should work but no particular inspection procedure

Data from 35 industry responses show that daily rental costs average $0.42 per unit; average battery life is approximately 18 days; and that battery costs contribute approximately 36 percent of the daily rental costs. A large proportion of the remainder of the daily rental cost is due to the need to replace units due to accidental damage, theft, or vandalism. Responses to a question, on the industry survey concerning the percentage of units lost each year due to these causes show the following, based on 34 separate replies:

Mean	32 percent
Standard Deviation	30 percent
Coefficient of Variation	0.94

As can be inferred from the relatively high value of the Coefficient of Variation, the replies covered a considerable range with a minimum of 3 percent and a maximum of "more than 100%". No geographical pattern that would explain this spread of responses could be discerned. In fact, one traffic control contractor who submitted separate responses for three district offices in the same State showed annual loss rates of 2, 25 and 50 percent. It should also be noted that a number of respondents commented that loss rates for Type C Warning Lights, which are predominantly used on limited access facilities, were lower than those for Type A (flashing) lights, which are more likely to be used on urban arterials.

The survey of State agencies included a question concerning operational problems encountered in the use of Class C steady-burning lights. Such problems, including vandalism, collision damage, loss of alignment, and other problems, were reported by 84 percent of those agencies which had usage patterns one or two.

	Usage Pattern	
	1 (Always)	2 (Sometimes)
Reported Problems	20	6
No Reported Problems	2	3
No Response	1	2

Several States reported considerable differences in the frequency of operational problems as a function of geographical area within the State, abutting land use, or highway functional classification. In the latter case, vandalism and theft frequency was generally lower on high-speed, limited access facilities.

MUTCD ISSUES

Three questions addressed, respectively, the adequacy of provisions, in the Manual of Uniform Traffic Control Devices (MUTCD) covering the use of Class C warning lights,

the need for specific changes in these provisions, and differences between State and Federal MUTCD.

Insofar as the adequacy of current MUTCD provisions is concerned, the responses reviewed were as follows:

Adequate	28	59.6%
Not Adequate	7	14.9%
No Response	12	25.5%

Reasons for inadequacy, when given, generally dealt with clarity, a lack of firm guidelines, and the need for standard drawings.

Sixteen of the 33 (48%) responses to the specific question believed that changes in the MUTCD should be made. In these responses also the changes requested were mostly for more specific application guidelines or for the explicit mention of alternate treatments, such as high intensity reflective sheeting.

Twenty-four respondents indicated that their State MUTCD did not differ from the Federal version in its treatment of Class C warning lights or that the State had adopted the Federal version. Twelve respondents indicated that there was a difference, and eleven did not respond to that question. Differences cited usually indicated that the State versions were more comprehensive, more restrictive, or more definitive.

The MUTCD requires (section 6E-5) that all warning lights shall conform to the requirements of the current ITE Purchase Specifications for these devices. These specifications cover mechanical and electrical details, as well as light output. A further requirement is that Type C steady-burn lights should be visible on a clear night from a distance of 3000 ft.

A question concerning the general adequacy and applicability of the ITE specifications yielded the following responses:

Adequate and Appropriate	25 (53.2%)
Inadequate or Inappropriate	1 (2.1%)
Not Familiar	5 (10.6%)
No Answer	14 (34.0%)

One response stated that that particular State had removed all references to the ITE specifications from the State's version of the MUTCD. Another response asserted that maintained performance, in accordance to ITE specifications, was not feasible.

Insofar as a question on the intensity requirements of the ITE specifications is concerned, responses were as follows:

About Right	28 (59.6%)
Too Low	4 (8.5%)
Too High	0 (0.0%)
No Answer	14 (31.9%)

One respondent answered that the requirements appeared to be about right but that more research was needed. Another stated that these requirements could neither be monitored nor maintained. It should also be noted that two respondents who indicated their unfamiliarity with the ITE specifications nevertheless indicated their opinion that these requirements were "about right".

A set of parallel questions, on the industry survey, referred to the 3000-ft visibility requirements of the MUTCD. The first of these questions referred to the respondents specific jurisdiction use of the 3000-ft requirement and elicited the following responses:

3000-ft requirement used	24
3000-ft requirement not used	9
No response	7

It should be pointed out that in at least three instances, the replies to this question from industry sources contradicted, directly or implicitly, similar information supplied in response to the survey of State agencies.

The second question dealt with the perceived adequacy of the 3000-ft requirement and received the following responses:

Adequate	30
Not Adequate	5
No response	5

Only one respondent indicated that a shorter recognition distance, specifically 2000 ft, might be sufficient.

SUMMARY AND CONCLUSIONS

Based on the responses received, the following conclusions concerning current usage patterns of Type C steady-burn lights in the United States can be stated:

- About three quarters of all the States generally or sometimes use steady-burn lights in highway work zones.
- These States, collectively, have 77.3 percent of all US arterial highway mileage and 69.8 percent of all arterial VMT.

- The use of steady-burn warning lights is highest in the Midwestern States and lowest in the Eastern US.

- Steady-burn warning lights are most likely to be used in conjunction with drums and barricades and less likely to be used with other channelization devices.

- Inspection requirements vary widely with only about one-third of the States using these devices explicitly requiring daily inspections.

- Less than 65 percent of the States using these devices report that contractors "generally" or "mostly" meet inspection and maintenance requirements.

- Traffic control contractors do not always interpret State inspection and maintenance requirements correctly.

- Theft and vandalism are serious problems, but their impact is highly variable.

- Almost 85 percent of all using States report some operational problems in the use of these devices.

- Eighty percent of the responding States believe that current MUTCD requirements are adequate; almost 50 percent, however. believe that changes in the MUTCD should be made.

- Eighty percent of the respondents believe that the ITE specifications are adequate and appropriate.

GUIDELINES FOR THE USE OF TRUCK-MOUNTED ATTENUATORS

Jack B. Humphreys, P.E.
Professor
Department of Civil Engineering
The University of Tennessee

T. Darcy Sullivan, P.E.
Transportation Consultant

INTRODUCTION

The hazardous nature of construction and maintenance work zones on and along streets and highways has been recognized for many years. Unfortunately, knowledge all too frequently is not translated into action; when it is, the time required for transition and implementation of newly developed procedures is sometimes lengthy. Only in recent years, for example, have we seen implementation of many of the principles set forth in the 1967 AASHTO publication Highway Design and Operational Practices Related to Highway Safety [1], frequently referred to as the 1967 Yellow Book. Specifically, that document stated that the use of traffic control plans; improvements in signing, channelization and pavement markings; portable barriers; better training of flaggers; arrow panels; changeable message signs; and improved construction scheduling can all combine to produce safer work zones.

During the late 1970's, work zone safety was considered an emphasis area by the Federal Highway Administration (FHWA). The impetus for this emphasis largely resulted from a fatal January 1975 work zone accident on the I-495 beltway around Washington, D.C. and subsequent legal action involving the FHWA and other governmental agencies. Research activity into the identification of work zone safety problems, with recommendations for specific research to address those safety problems, was completed in 1979. [2] Extensive changes were incorporated into Part VI of the 1978 Manual on Uniform Traffic Control Devices (MUTCD) [3], many reflecting the principles set forth in the 1967 Yellow Book. [1] Even further changes are noted in the 1989 MUTCD, [4]

To improve work zone accident statistics, both in magnitude and cost, agencies have promoted work zone safety in a variety of ways. Extensive training programs have been undertaken by many States. Training in work zone safety is also offered by the American Traffic Safety Services Association (ATSSA), the Institute of Transportation Engineers (ITE), the National Highway Institute (NHI), and others.

In addition to training, the use of more extensive traffic control plans and the upgrading of traffic control devices have both improved and emphasized the need for better work zone traffic controls.

HISTORY OF TRUCK-MOUNTED ATTENUATORS

During the 1950's, highway agencies became aware of the large number of fixed roadside hazards that were playing an increasing role in the number of fatalities and injuries. In addition to a realization that such hazards should be removed or relocated, attention was directed to the mitigation of the results of such fixed object impacts. Crash cushions, or impact attenuators, were considered and development began.

One of the first such attenuators was the steel-drum crash-cushion system developed in Texas in the mid-1960's. [5] Extensive research and development by Federal and State governmental agencies and by the highway safety industry has since produced a wide variety of impact attenuators which can be adapted to varying site-specific highway conditions or needs. These include water-filled tubes; sand-filled plastic barrels; and crushable, dry energy-absorbing materials.

Success with these crash-cushion designs has stimulated development of mobile systems which are attached to work vehicles. Perhaps the first of these was the Texas Crash Cushion Trailer, developed and tested in 1972. [6,7] From this early attenuator, other truck-mounted attenuator (TMA) systems soon followed. Designs to date include the following: [6]

- Energy-absorbing cartridges within a frame (Hex-Foam, by Energy Absorption Systems, Inc. [EASI]).
- Aluminum Honeycomb w/frame (Hexcel, by Hexcel, Inc.; Alpha 1000, by EASI; Alpha 500, by EASI).
- Water-filled tubular vinyl cells (CushionSafe, by Transpo-Safety, Inc.).
- Collapsing (or crushing) steel pipe (developed by University of Connecticut).

The highway safety industry has made extensive improvements to first generation TMA's. Designs now provide for consistently safe G-load levels for both light and heavy automobiles over a range of impact speeds, as well as increased maneuverability of truck-TMA units due to a tilt-up option with hydraulically activated latching and other improvements. Overall weights of TMA units have decreased, and the time (and difficulty) of mounting and unmounting the devices from trucks has been greatly reduced. Current TMA designs are, thus, more effective and easier to utilize with a vehicle fleet.

With the emphasis on work zone safety exhibited by the FHWA and others, improvements in the level of traffic control provided are quite evident. Unfortunately, TMA's have not been readily and uniformly accepted across the United States. Several factors have apparently contributed to this lack of acceptance, among them the following:

- Negative experience with first generation TMA's, including mounting procedures, inadequate tilt capabilities, etc.

- Perceived loss of productive work time without significant gain in safety for employees.

- Truck tie-up (with dedicated TMA usage).

- Lack of positive local accident experience within the agency.

- Initial cost of TMA's.

- The fact that TMA's are not required by MUTCD.

- Lack of widespread (national) policy and/or procedures for TMA usage (this includes both where and how a TMA should be used).

A partial review of 1980's TMA experience across the States provides some indication of the lack of uniformity in TMA usage during that period. Perhaps the earliest most specific reference to TMA use was added in July 1981 to the MUTCD in one State, reading as follows:

> At stationary work areas, a shadow vehicle with an attenuator fastened to the rear should be placed upstream of the work area. For moving work areas, the attenuator should be placed on the rear of the work equipment and/or shadow vehicle. (Source intentionally not included.)

While this text appears to provide sufficient direction and would suggest extensive TMA use, apparently that State, as of early 1990, has only four TMA units within the highway department--certainly not enough to meet the "requirements" of their MUTCD.

By 1982, the Oakland County, Michigan, Road Commission had one TMA for each of its seven operating districts. Four additional TMA's were purchased in 1985 for use in its more urban districts. [8]

By 1984, the Texas Department of Highways and Public Transportation had several TMA's in use. Each Texas highway district has funds to purchase equipment, with acquisitions to be approved by headquarters personnel. Region 2, headquartered in Fort Worth, was using two units full time in restriping operations alone. They also maintained five TMA cartridges in inventory to meet immediate replacement needs. [9]

A 1985 report on highway safety devices, prepared for the Texas legislature by the Texas Department of Highways and Public Transportation, estimated the value of a TMA in such accidents. A per accident savings of $23,000 in injury and damages was estimated

for a vehicle hitting a TMA instead of a stationary vehicle, resulting in a very favorable benefit-cost ratio. [10]

Other States moved quickly to utilize TMA's in their operations. By 1987, California had approximately 500 in use. By that time, policy required a TMA on the rearmost vehicle in a "work-in-progress" operation. All vehicles moving significantly slower than prevailing traffic, such as in sweeping or painting operations, also had to be equipped with a TMA. CALTRANS feels that the life-saving benefits to motorists and workers have made the crash cushions worthwhile. In addition, savings have been recognized in the repair and replacement of damaged equipment.[11]

In 1986, a task force was appointed by the North Carolina State highway chief engineer to develop recommendations concerning safer operations for slow moving maintenance work. A summary of guidelines for maintenance operations was prepared in 1987. While many of the operations required only rotating beacons on the equipment (such as contour mowers and broom tractors), shadow vehicles with TMA's were recommended for herbicide spraying operations and painting operations utilizing cones, while edge line painting (without cones) had the TMA optional on the trailing vehicle. Those guidelines did not address the issues of exposed personnel on foot doing patching, sealing, or other similar work.

A 1988 shadow vehicle policy distributed to all New York regional highway engineers addressed the issue of the required use of shadow vehicles. However, the policy indicated that TMA's were not required on those vehicles, but would be utilized "if available and where practical" on both moving and stationary operations on multilane highways. They would be used on two-lane highways "if desirable."

After a St. Louis vehicle struck a TMA involved in a striping operation, with the motorist escaping serious injury, the Missouri Highway Department studied increasing TMA usage by their forces. Plans were developed in 1989 to attach TMA's to departmental vehicles performing routine maintenance operations.[12] Similarly, Florida Department of Transportation officials drafted a set of guidelines for the use of protective equipment, but as of 1989, each district had authority in the decision to require such equipment. In some cases, TMA's are required, such as on contract sweeper operations in Duval County.

Georgia also has developed guidelines for protective equipment, but, as in Florida, those guidelines are not mandatory, and the language is quite broad. As the assistant State maintenance engineer has stated, TMA's are required "in any instance where there's a high likelihood of impact in an open lane situation." [13]

More definitive requirements for TMA usage appeared in the 1987 Virginia Work Area Protection Manual, which is a supplement to the Virginia MUTCD; thus, its use is mandatory. Both "the 1987 manual and its 1988 revision establish a number of conditions

where TMA's are to be used. . . . After July 1, 1988, TMA's were required on all limited access highways," using the following criteria:[14]

- Pavement marking.
- Stationary lane closures.
- Other mobile maintenance operations.
- Other situations, as warranted.

PURPOSE OF THIS RESEARCH

As suggested above, there is a great variance in usage of TMA's among the States, with some States having virtually none, while California has over 500 in use. Even in those States with a number of TMA's, guidelines for usage are in general loosely worded, giving field personnel a great deal of leeway in their application. It would appear appropriate to develop some set of nationally accepted guidelines, warrants, or priorities for usage in order to obtain the usage having the highest probability of increasing overall safety and reducing total costs. The purpose of this research, then, is to address this issue by suggesting priorities as to how and where available TMA's should be deployed. Then, given the availability of one or more TMA's, supervisory personnel would be able to assign them more effectively on a day-to-day basis. Also, if a priority system can be agreed upon within a given agency, the total number of TMA's required to cover a certain level of priority can be estimated more accurately.

DEVELOPMENT OF GUIDELINES

Several States were selected as candidate contacts to determine the status of current TMA programs. The States represented a range of attributes with respect to the following:

- Geographic location.
- Apparent interest in the use of TMA's.
- Number of units in active use.

The States were contacted to determine their willingness to discuss their use of TMA's with the research staff. Initial contacts with the States simply suggested the possibility of a meeting to discuss how TMA's were being used within the agency and what their experiences (good and bad) had been. States ultimately selected for participation in the process were California, Iowa, North Carolina, Tennessee, and Texas.

Discussion sessions were held during July and August of 1989. Agency personnel attending the sessions were selected by the agency and ranged in number from three to seven. Job responsibilities of those in attendance included maintenance foremen, supervisors, and engineers; traffic engineers and technicians; purchasing agents; occupational safety and training officers; garage repair personnel; and construction engineers.

During the discussions agency personnel were invited to comment on the origins of their TMA programs, the general availability of TMA's to field personnel, the most common applications, the basis for the assignment of application priorities, and the acceptance of the devices by a broad range of agency personnel. Although there was a wide range of responses on the number of TMA's presently in active use (from fewer than 10 to over 500), there was far more consistency from State to State on other issues discussed. Some of the issues on which there were strong similarities included the following:

- The initial support for the use of TMA's came principally from the administrative level.

- Support for the use of TMA's among field personnel was generally good to very good in States using the tilt-up versions of the TMA. Support among field personnel was absent where available units did not incorporate the more recent technologies, including the tilt-up feature and reasonably easy mounting and dismounting of the units.

- Reported uses, in order of reported frequency, included maintenance activities, construction activities, and emergency incident management. The use of TMA's on shadow vehicles to moving operations was, by policy, the most common application. The safety of exposed personnel was the primary concern of the field forces.

- There seemed to be little factual basis for any existing application policies.

Based on the information gathered during the agency visits, a draft of suggested TMA-use guidelines was prepared. Those guidelines attempted to reflect the existing practice of the agencies, the expressed concerns of the field personnel who participated, and the experience of the researchers. These draft guidelines were presented to a large group of industry personnel to determine how they thought such information would be received by various agencies. The draft was modified and then was taken back to two of the States originally visited seeking firsthand response. The response was generally favorable, but the guidelines were seen as too complicated to be used by field personnel.

The material was again revised to simplify the format and provide more agency flexibility in the application of the suggested guidelines. Draft materials then were distributed to those in attendance at the January 1990 committee meetings of the

Transportation Research Board A2A04 Committee on Roadside Safety Appurtenances and A3C04 Committee on Traffic Safety in Maintenance and Construction Operations. Committee members and others in attendance were asked to review the draft guidelines and were invited to provide comments later on either the content or format of the guidelines.

Based on input from the described sources and a number of other informal contacts by the project staff, a final set of guidelines was developed.

RECOMMENDED GUIDELINES

Before a set of priorities can be established for the uses of TMA's, a system must be available for defining the type of activity taking place. Factors which have been previously identified as affecting the type and number of traffic control and protective devices to be used and how they are used include the following:

- Speed of traffic.
- Whether the work area is within the roadway, within the shoulder (if one is present), or off the roadway or shoulder.
- Type of activity: moving, intermittent, or stationary.
- Roadway environment: access controlled vs. nonaccess controlled; urban vs. rural.
- Traffic volumes.
- Exposure to special hazards.

While many factors may be important in determining the overall traffic control plan to be implemented at any particular job site, five were selected as particularly relevant to a decision whether or not to use a TMA. Three of those factors are as follows:

- LOCATION OF WORK AREA. Locations of primary concern are those within the travelled lanes and those within all-weather frequently used shoulders.
- TYPE OF ACTIVITY. Whether the activity is moving, intermittent, or stationary will determine whether or not a standard lane closure or shoulder closure will be implemented. Activities taking place within a formal lane or shoulder closure are less likely to become involved in an incident than are activities fully exposed to approaching traffic.
- SPECIAL HAZARDS. Some activities by their very nature expose personnel to greater hazards than do others. Operations involving personnel on foot or located

in exposed positions on or within work vehicles (on the platform of a cone pickup truck or in a bucket performing overhead operations, for example) are particularly susceptible to high severity incidents. Other activities may create conditions which present a significant hazard to vehicles in the passing stream and their occupants.

Table 1 provides a structure for classifying various activities considering the previously discussed lane/shoulder closure and exposure conditions. Examples of typical construction and maintenance activities for each of the closure/exposure conditions also are provided.

Tables 2 and 3 suggest priorities for the assignment of shadow/barrier vehicles and TMA's. Two additional factors which were identified as having an impact on assignment priorities are reflected in these tables.

- ACCESS CONTROL. Access controlled facilities frequently give drivers a false sense of security with a resulting lower expectation of interruptions to free traffic flow. Therefore, activities on freeways may be more likely to become involved in incidents.

- SPEED LIMIT. Higher operating speeds leave less time for response, and impacts at higher speeds generally result in more severe injuries and damage.

During the interviews with agency personnel, it was obvious that many of the field personnel felt strongly that the use of a blocking vehicle (generally referred to as a shadow vehicle for moving and intermittent operations and a barrier vehicle for stationary operations) was highly desirable for the protection of exposed personnel even if a TMA was not available. Many agencies have a policy regarding the use of blocking vehicles. Those that do may desire to continue to follow that policy. Table 2 suggests priorities which are consistent with the expressed concerns of the field personnel and may be considered where no policy currently exists.

From an examination of Table 2 it is obvious that the suggested priorities for the assignment of blocking vehicles are tied directly to protection of agency personnel. In each case where personnel are exposed, a positive recommendation is provided with the strength of that recommendation dependent on the closure condition, the prevailing speed of traffic, and whether or not the operation is occurring on a freeway.

Where exposed personnel are not involved, the use of a blocking vehicle may or may not be justified. That decision will depend on an evaluation of the hazards which exist within the work area and the likely loss if a blocking vehicle is struck. If the evaluation indicates that impact with a blocking vehicle is likely to result in less damage and/or less serious injury than would impact with a work area hazard or a working vehicle, then a blocking vehicle should be assigned to the operation. If the projected damage or injury is greater, then the vehicle should not be assigned. For example:

Table 1

EXAMPLES OF CLOSURE/EXPOSURE CONDITIONS

Closure/Exposure Condition	Examples of Typical Construction/Maintenance Activities	See Figure
No Formal Lane Closure		
Shadow Vehicle for Operation Involving Exposed Personnel	Crack pouring, patching, utility work, striping, coning	1
Shadow Vehicle for Operation Not Involving Exposed Personnel	Sweeping, chemical spraying	1
No Formal Shoulder Closure		
Shadow Vehicle for Operation Involving Exposed Personnel	Pavement repair, pavement marking, delineator repair	2
Barrier Vehicle for Operation Not Involving Exposed Personnel	Open excavation, temporarily exposed bridge pier	2
Formal Lane Closure		
Barrier Vehicle for Operation Involving Exposed Personnel	Pavement repair, pavement marking	3
Barrier Vehicle for Condition Involving Significant Hazard	Open excavation	3
Formal Shoulder Closure		
Barrier Vehicle for Operation involving Exposed Personnel	Pavement repair, pavement marking, guardrail repair	4
Barrier Vehicle for Condition Involving Significant Hazard	Open excavation	4

Definitions:

A FORMAL CLOSURE condition (either lane or shoulder) includes a full complement of advance warning devices, a closure taper of channelizing devices, and channelizing devices to define the work area as required.

A NO FORMAL CLOSURE condition (either lane or shoulder) includes limited (if any) advance warning signs and channelizing devices.

A SHADOW VEHICLE is a moving vehicle traveling a short distance upstream from a moving operation giving physical protection from approaching traffic.

A BARRIER VEHICLE is a vehicle parked a short distance upstream from a stationary operation giving protection from approaching traffic.

Table 2

SUGGESTED PRIORITIES FOR THE ASSIGNMENT OF SHADOW/BARRIER VEHICLES

Closure/Exposure Condition	Ranking*			
		Non-Freeway with Speed Limit		
	Freeway	≥50 mi/h	40-45 mi/h	≤35 mi/h
No Formal Lane Closure				
Shadow Vehicle for Operation Involving Exposed Personnel	A	A	A	A
Shadow Vehicle for Operation Not Involving Exposed Personnel	E	E	E	E
No Formal Shoulder Closure				
Shadow Vehicle for Operation Involving Exposed Personnel	B	B	C	C
Shadow Vehicle for Operation Not Involving Exposed Personnel	E	E	E	E
Formal Lane Closure				
Barrier Vehicle for Operation Involving Exposed Personnel	B	B	C	D
Barrier Vehicle for Condition Involving Significant Hazard	E	E	E	E
Formal Shoulder Closure				
Barrier Vehicle for Operation Involving Exposed Personnel	C	C	D	D
Barrier Vehicle for Condition Involving Significant Hazard	E	E	E	E

*The ranking letter indicates the priority assigned to the use of a shadow/barrier vehicle. The use of shadow/barrier vehicles:

- A is very highly recommended.
- B is highly recommended.
- C is recommended.
- D is desirable.
- E may be justified on the basis of special conditions encountered on an individual project when an evaluation of the circumstances indicates that an impact with a shadow/barrier vehicle is likely to result in less serious damage and/or injury than would impact with a working vehicle or the hazard.

Table 3

SUGGESTED PRIORITIES FOR THE APPLICATION OF TRUCK-MOUNTED ATTENUATORS

Closure/Exposure Condition	Ranking*			
		Non-Freeway with Speed Limit		
	Freeway	≥50 mi/h	40-45 mi/h	≤35 mi/h
No Formal Lane Closure				
Shadow Vehicle for Operation Involving Exposed Personnel	1	2	3	4
Shadow Vehicle for Operation Not Involving Exposed Personnel	1	2	3	4
No Formal Shoulder Closure				
Shadow Vehicle for Operation Involving Exposed Personnel	2	3	3	3
Shadow Vehicle for Operation Not Involving Exposed Personnel	2	3	4	5
Formal Lane Closure				
Barrier Vehicle for Operation Involving Exposed Personnel	2	3	4	5
Barrier Vehicle for Condition Involving Significant Hazard	2	3	4	5
Formal Shoulder Closure				
Barrier Vehicle for Operation Involving Exposed Personnel	3	4	5	5
Barrier Vehicle for Condition Involving Significant Hazard	3	4	5	5

*The numerical rank indicates the level of priority assigned to the use of a TMA on an assigned shadow/barrier vehicle. The use of a TMA under the defined conditions is:

1 is very highly recommended.
2 is highly recommended.
3 is recommended.
4 is desirable.
5 may be justified on the basis of special conditions encountered on an individual project.

- An open excavation several ft deep and several ft across exists on a street in a residential area. A horizontal curve restricts sight distance to the excavation to less than desirable for the 25-mi/h speed limit. An impact with an appropriate blocking vehicle at 25 mi/h would probably result in less damage than would driving into a major excavation. Therefore, the use of the blocking vehicle would be appropriate.

- A full depth portland cement concrete patch has been placed and is curing in the right lane of an arterial street with prevailing speeds of 40+ mi/h. An impact with an appropriate blocking vehicle at 40 mi/h would probably result in greater loss (in both personal and economic terms) than would driving into an uncured patch which might then have to be replaced. Therefore the use of the blocking vehicle would be inappropriate.

Table 3 contains suggested priorities for the assignment of available TMA's. From an examination of Table 3 it is obvious that the suggested priorities for the application of TMA's are based primarily on the protection of the approaching motorists. The highest priority is on a freeway where speeds are high and the probability of an impact is greatest. Where, due to either the location of the activity or the presence of a formal closure, the probability of an impact is less, a lower priority is assigned.

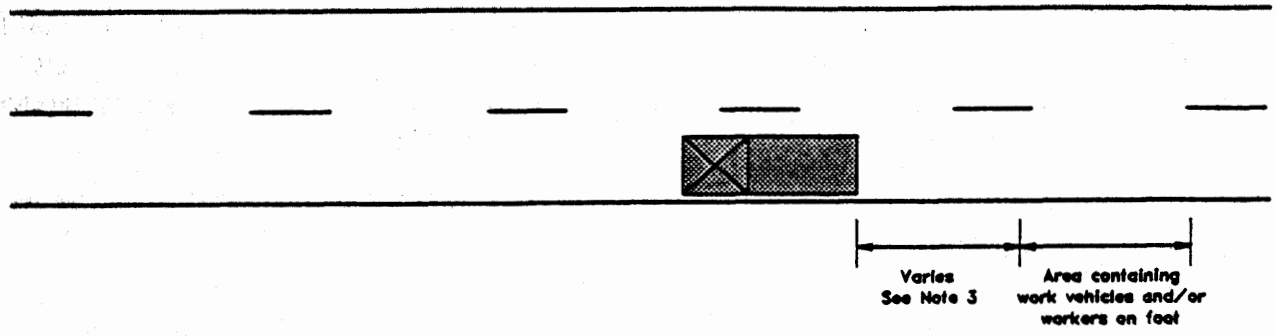
Figures 1-4 illustrate the use of TMA-equipped vehicles in the closure/exposure conditions identified in Table 1. The relative simplicity of the illustrations compared to illustrations in the MUTCD may be misleading, and the following items should be noted:

- In most cases the use of traffic control devices in the Advance Warning Area and Transition Area, as defined in the Traffic Control Devices Handbook [15], will be appropriate. Because this topic is adequately covered in the MUTCD, in other agency policies, and, where applicable, in the project traffic control plan, those details are not repeated on the figures.

- Figure 1 specifically recommends an arrow panel on the TMA equipped vehicle. In all of the other figures, it is indicated as an option.

- Where a formal lane closure or shoulder closure is implemented, a Buffer Area (or Buffer Space as defined in the Traffic Control Devices Handbook) is typically provided. Because this topic is adequately covered in the Handbook, the MUTCD, in other agency policies, and, where applicable, in the project traffic control plan, those distances are not repeated on the figures.

- When a blocking vehicle is hit, it will be moved forward some distance. That distance is commonly referred to as the "roll-ahead distance" and varies depending on the weights and speeds of the two vehicles involved, the extent to which the blocking vehicle is restrained, and certain pavement characteristics. All of the factors, except vehicle weights and impacting vehicle speed, can be accounted for



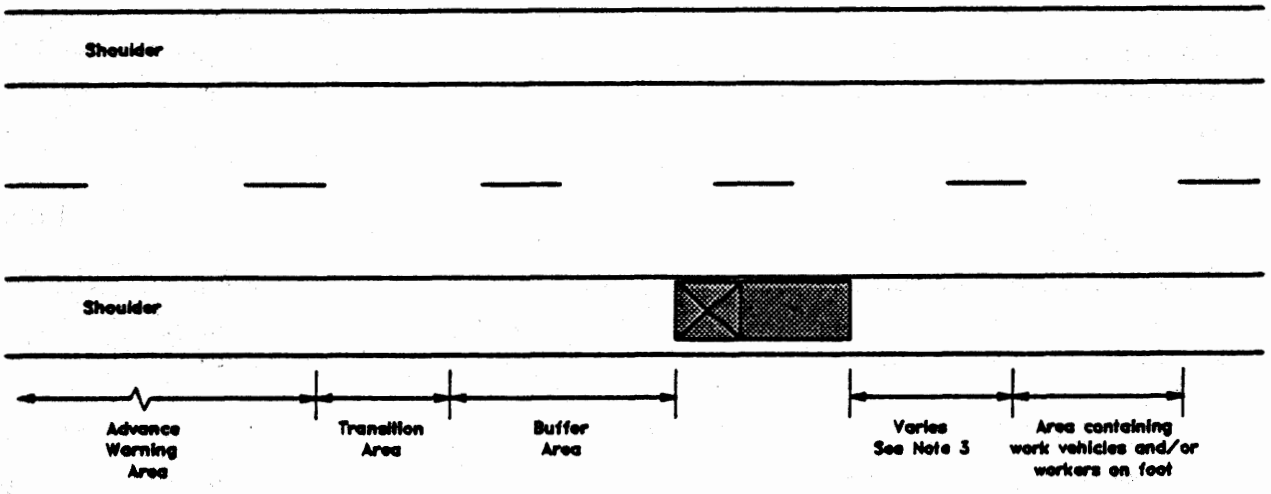
Notes:
1. Advance warning traffic control devices to be in accordance with MUTCD, TCP, or other agency policies.
2. TMA vechicle should be equipped with an arrow panel operated in accordance with the MUTCD, TCP, or other agency policies.
3. Variable intervening distance to be selected from the following table:

Legend:

Vehicle with Attenuator

Prevailing Speed (mph)	TMA Vehicle Stationary (ft.)	TMA Vehicle Moving (ft.)
60–65	Appropriate buffer distance to be obtained from Table 4 or 5 based on policy decision defining shadow/barrier and impacting vehicle weights	
50–55		
≤ 45		

Figure 1 - Work area outside formal lane closure. (One-way or two-way)



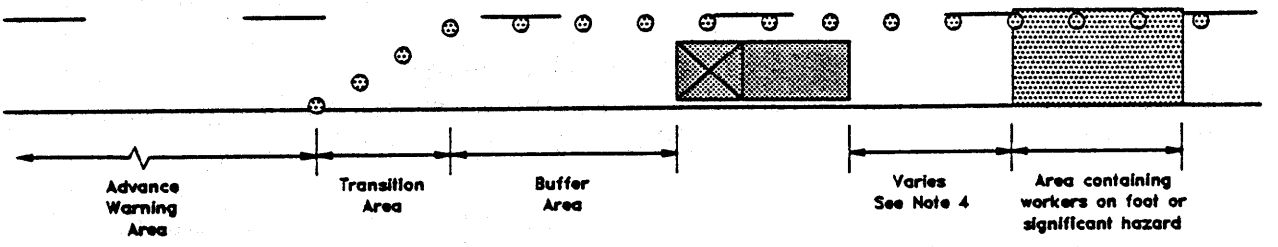
Notes:
1. Advance warning traffic control devices to be in accordance with MUTCD, TCP, or other agency policies.
2. If the TMA vechicle is equipped with an arrow panel, it is to be operated in accordance with the MUTCD, TCP, or other agency policies.
3. Variable intervening distance to be selected from the following table:

Legend:

Vehicle with Attenuator

Prevailing Speed (mph)	TMA Vehicle Stationary (ft.)	TMA Vehicle Moving (ft.)
60–65	Appropriate buffer distance to be obtained from Table 4 or 5 based on policy decision defining shadow/barrier and impacting vehicle weights	
50–55		
≤ 45		

Figure 2 - Work area on shoulder without formal shoulder closure.



Notes:

1. Advance warning and transition area traffic control devices to be in accordance with MUTCD, TCP, or other agency policies.
2. If the TMA vechicle is equipped with an arrow panel, it is to be operated in accordance with the MUTCD, TCP, or other agency policy.
3. Minimum buffer area length to be in accordance with TCP or agency policy.
4. Variable intervening distance to be selected from the following table:

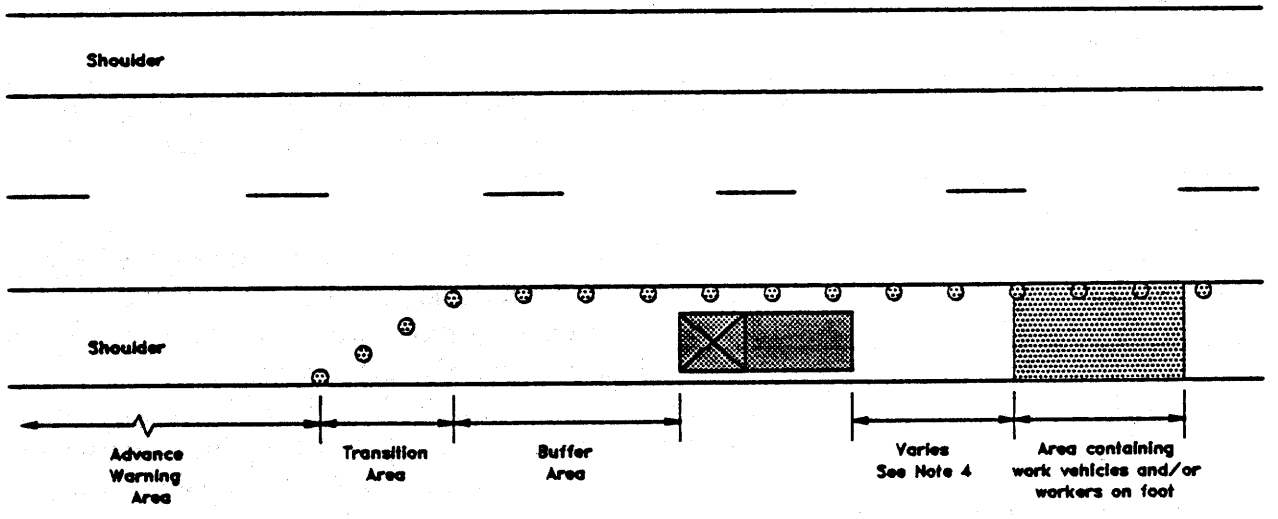
Prevailing Speed (mph)	TMA Vehicle Stationary (ft.)	TMA Vehicle Moving (ft.)
60–65	Appropriate buffer distance to be obtained from Table 4 or 5 based on policy decision defining shadow/barrier and impacting vehicle weights	
50–55		
≤ 45		

Legend:

Channelizing Device

Vehicle with Attenuator

Figure 3 - Workers on foot or significant hazard within formal lane closure. (One-way or two-way)



Notes:

1. Advance warning and transition area traffic control devices to be in accordance with MUTCD, TCP, or other agency policies.
2. If the TMA vechicle is equipped with an arrow panel, it is to be operated in accordance with the MUTCD, TCP, or other agency policy.
3. Minimum buffer area length to be in accordance with TCP or agency policy.
4. Variable intervening distance to be selected from the following table:

Prevailing Speed (mph)	TMA Vehicle Stationary (ft.)	TMA Vehicle Moving (ft.)
60–65	Appropriate buffer distance to be obtained from Table 4 or 5 based on policy decision defining shadow/barrier and impacting vehicle weights	
50–55		
≤ 45		

Legend:

Channelizing Device

Vehicle with Attenuator

Figure 4 - Work area on shoulder with formal shoulder closure.

with a series of assumptions. The likely speed of the impacting vehicle is site specific. The weight of the units used as blocking vehicles and the weight of the impacting vehicle to be accommodated by the system are both policy issues.

Tables 4 and 5 provide a listing of calculated and rounded roll-ahead distances for various vehicle weight/speed conditions. Calculations were made utilizing the classical conservation of momentum equation and the following assumptions:

- Coefficients of friction between truck tires and pavement surface of 0.50.
- Percent of total vehicle weight on rear axles of shadow/barrier vehicles equal to 75 percent.
- Engine braking effectiveness of moving shadow vehicle equal to 80 percent.
- Values rounded downward as appropriate.

Appropriate values reflecting the agency's policy decisions should be taken from Tables 4 and 5 and inserted in the figures before the figures are distributed for use by field forces.

CONCLUSIONS

This research effort has resulted in guidelines which will assist in determining the priority of usage of barrier or shadow vehicles and of TMA's. Additional guidelines relating to the actual usage of TMA's are presented.

TMA's have been available for several years, but their use in most States has been limited. As a result, there are no comprehensive guidelines or suggested application priorities. Soon after the study started, the researchers recognized that there was not an existing data base which would support a rigorous scientific analysis and that a comprehensive scientific study would require information derived from TMA use over a diverse geographical area under a wide range of work zone types. Required data would include the number and severity of accidents (with and without TMA's) by work zone activity and some measure of the frequency of exposure and activities.

While no scientific work plan was developed, it appeared obvious that developing an adequate data base would require the cooperation of a number of agencies, over an extended period of time, at a cost which would probably be measured in the hundreds of thousands of dollars--far beyond the budget available for this effort. In the meantime, there was a short-term need for a rational basis for assigning available units. This report was prepared in an effort to fill that need.

Table 4

ROLL-AHEAD DISTANCE FOR SHADOW VEHICLES

Weight of Shadow Vehicle (moving)[b]	Prevailing Speed (mi/h)	Weight of Impacting Vehicle to be Contained[a] 4,500 lb	10,000 lb	15,000 lb	24,000 lb
10,000 lb	60-65	100 ft	175 ft[c]	225 ft	275 ft
	50-55	100 ft	150 ft[c]	175 ft	200 ft
	≤45	75 ft	100 ft[c]	125 ft	150 ft
15,000 lb	60-65	75 ft	150 ft	175 ft	225 ft
	50-55	75 ft	125 ft	150 ft	175 ft
	≤45	50 ft	100 ft	100 ft	100 ft
24,000 lb	60-65	75 ft	100 ft	150 ft	175 ft
	50-55	50 ft	75 ft	100 ft	150 ft
	≤45	50 ft	75 ft	75 ft	100 ft

[a]Weights of typical vehicles: mid-size automobile, 2,250 lb; full-size automobile, 3,500 lb; loaded 3/4-ton pickup truck, 6,000 lb; loaded 1-ton cargo truck, 10,000 lb; loaded 4-yard dump truck 24,000 lb.

[b]Distances are appropriate for shadow vehicle speeds up to 15 mi/h.

[c]Values suggested for inclusion on Figures 1, 2, 3, and 4.

Table 5

ROLL-AHEAD DISTANCE FOR BARRIER VEHICLE

Weight of Barrier Vehicle (stationary)[b]	Prevailing Speed (mi/h)	Weight of Impacting Vehicle to be Contained[a] 4,500 lb	10,000 lb	15,000 lb	24,000 lb
10,000 lb	60-65	50 ft	100 ft[b]	150 ft	200 ft
	50-55	25 ft	75 ft[b]	100 ft	150 ft
	≤45	25 ft	50 ft[b]	75 ft	100 ft
15,000 lb	60-65	25 ft		75 ft	100 ft
	50-55	25 ft	50 ft	75 ft	100 ft
	≤45	25 ft	25 ft	50 ft	75 ft
24,000 lb	60-65	25 ft	50 ft	75 ft	100 ft
	50-55	25 ft	25 ft	50 ft	75 ft
	≤45	25 ft	25 ft	25 ft	50 ft

[a]Weights of typical vehicles: mid-size automobile, 2,250 lb; full-size automobile, 3,500 lb; loaded 3/4-ton pickup truck, 6,000 lb; loaded 1-ton cargo truck, 10,000 lb; loaded 4-yard dump truck 24,000 lb.

[b]Distances are appropriate for shadow vehicle speeds up to 15 mi/h.

The guidelines reflect the existing practices of the agencies contacted, the concerns expressed by field personnel who participated in the discussions, and the collective wisdom of the researchers and others (including agency representatives, other researchers, suppliers representatives, etc.) from whom comments were sought and received. Priorities based on scientific research would be desirable and ultimately will be developed. The researchers hope that the present effort will stimulate discussion toward that end and believe that the guidelines in their present form can be used appropriately as a policy formation and budgeting tool.

REFERENCES

1. Highway Design and Operational Practices Related to Highway Safety, American Association of State Highway Officials, Washington, D.C., 1967.

2. Humphreys, Jack B., et al., "Identification of Traffic Management Problems in Work Zones," Report No. FHWA-RD-79-4, Federal Highway Administration, December 1979.

3. Manual on Uniform Traffic Control Devices, U.S. Department of Transportation, Federal Highway Administration, 1978.

4. Manual on Uniform Traffic Control Devices, U.S. Department of Transportation, Federal Highway Administration, 1988.

5. Tamanini, F.J., "Impact Attenuators: An Overview of Their Characteristics and Effectiveness," undated.

6. Buth, C.E., et al., "Truck Mounted Attenuators," Report No. FHWA-TS-88-018, Texas Transportation Institute, College Station, Texas, March 1988.

7. Marquis, E.L., and Hirsch, T.J., "Texas Crash Cushion Trailer to Protect Highway Maintenance Vehicles," Research Report 146-6, Texas Transportation Institute, August 1972.

8. EASI-Reader, Volume 5, Number 2, Energy Absorption Systems, Inc., 1985.

9. EASI-Reader, Volume 4, Number 2, Energy Absorption Systems, Inc., 1984.

10. Anderson, Roy W., Transafety Reporter, November 1988.

11. EASI-Reader, Volume 7, Number 1, Energy Absorption Systems, Inc., 1987.

12. EASI-Reader, Volume 9, Number 1, Energy Absorption Systems, Inc., April 1989.

13. "Increasing Work Zone Safety," Public Works, March 1989.

14. Anderson, Roy W., Transafety Reporter, April 1989.

15. Traffic Control Devices Handbook, U.S. Department of Transportation, Federal Highway Administration, 1983.

SAFE DEPLOYMENT OF WORK ZONE TRAFFIC CONTROL DEVICES

Jerry Hietpas
President
Action Safety Supply Co.

The techniques for the safe deployment of work zone traffic control device systems includes the following:

- Have trained traffic personnel analyze construction plans.
- Communicate with road contractor personnel to get feel for timing and construction phasing of project.
- Visit site to get familiar with geometry of roadway and answer the following six questions:
    1. What type of work is going to take place? Moving, mobile, or stationary?
    2. What location is the project to take place? Roadway, shoulder, or right-of-way?
    3. How much time is involved for the project?
    4. What type of facility is being worked on? Freeway, urban, side street?
    5. What is the traffic speed?
    6. What is the traffic volume?
- When on the site, check and locate utility lines that might conflict.
- Write the script for the deployment of work zone traffic control, which is a detailed list of the sequence of events that takes place on the work zone control plan. Give order and approximate time to complete each of the events. It is important to keep transition time between each phase of construction to a minimum.
- Look for any conflicts in the script and discuss them with all personnel involved.
- Schedule the putting up and taking down of work zone control devices to

avoid peak periods of traffic.

- Pretrip preparation:
  - * Check vehicles and uniforms.
  - * Load truck in reverse order of installation.
  - * Add temporary signs for your own work zone traffic control.
  - * Tie load securely.
  - * Make last check of all equipment.
- Install work zone traffic control devices:
  - * Never block roadway.
  - * Control traffic during the installation process.
  - * Install the traffic control devices in a downstream direction.
  - * Install temporary signs first to protect workers while installing more permanent work zone signs and devices.
  - * Plan escape route while on roadway.
  - * Never turn back to traffic.
  - * Use truck as additional warning device and protection.
  - * Don't obstruct work zone devices.
  - * Be aware of traffic at all times.
  - * Prepare devices before hand and then just snap them in place when on the road.
  - * Plan movement within work zone to minimize entering and exiting.
- To remove work zone traffic control devices:
  - * Reverse the installation procedure.
  - * Avoid driving against traffic flow.

* Minimize time within work zone.

- Tips:

  * Have thorough knowledge of standards and plans.

  * Communicate with supervisor, the contractor, and other project personnel.

  * Check vehicles, tools, and equipment.

  * Scout job site ahead of time.

  * Park carefully and legally at the job site.

  * Plan escape route.

  * Avoid shortcuts.

  * Stay alert.

PLANNING AND SCHEDULING FREEWAY LANE CLOSURES

Raymond A. Krammes
Assistant Professor of Civil Engineering
Texas A&M University

INTRODUCTION

As the need for maintenance and rehabilitation of our aging freeway system has increased and traffic demands have grown, State highway agencies have become increasingly sensitive to the safe and efficient handling of traffic through freeway work zones. The frequency of required maintenance activities and the potential severity of the traffic disruptions caused by work zones have heightened the importance of careful planning and scheduling of lane closures for maintenance and construction activities. This paper discusses ways of estimating the additional road user costs due to freeway work zone lane closures so that the total cost of work activities may be accounted for in planning and scheduling decisions.

THE PROBLEM

The problem faced by highway agencies in maintaining and rehabilitating our Nation's freeways is similar to the problem faced by surgeons who must repair a body's vital arteries while still maintaining the flow of blood. Traffic is the lifeblood of our economy, and the flow of traffic must be maintained while road work is being performed.

Roadway space is a scarce resource that must be allocated between the required work activities and the motorists. In planning and scheduling freeway work zone lane closures, trade-offs between the requirements of the work activity and the requirements of motorists must be carefully considered.

Decisions about when and where to close how many lanes have significant cost implications. Costs that must be considered in making such decisions include:

- The costs borne by the highway agency, including the actual cost of performing the work activity by contract or agency forces, the cost of installing and removing the traffic control devices necessary to accommodate traffic safely through the work zone, and the cost of administering and inspecting maintenance or construction contracts.

- The additional road user costs, including the increased travel time, vehicle operating, and accident costs resulting from the work zone.

The costs borne by the highway agency are paid by revenues derived largely from user fees. Therefore, ultimately, the road user pays the total cost of maintenance and construction activities. When viewed from this perspective, it seems reasonable that lane closures for maintenance and construction activities be planned and scheduled so as to minimize the total cost of the work activity.

BIDDING CONCEPTS BASED UPON MINIMIZING TOTAL PROJECT COST

Several bidding concepts have been developed based upon the objective of minimizing the total cost of the work activity. One technique is the cost/time bidding concept, in which "each bidder proposes a time duration for the project and traditional unit prices for the work items. A road user cost is applied to the proposed contract times. The low bidder is determined as the proposal which provides the lowest combination of bid cost and total user cost." [1]

Ellis and Herbsman[1] reached the following conclusion based upon an evaluation of 16 projects in which this concept has been applied:

> Using both time and base-bid cost as criteria for determining the low bidder on highway construction projects has been shown to be a successful innovation. It does not change the fundamental concepts of the low bidder system, but it does incorporate an additional element (time) to the low bidder selection criteria. Although the number of trial projects is relatively small, the results indicate that substantial savings in project time can be obtained without significant increases in basic construction cost. The net savings to the public, calculated by including the Road User Daily Cost, makes an impressive argument for use of the cost/time bidding system.

A variation on the cost and time method is the lane rental concept, in which "lane rental" fees for lane closures are specified based upon the road user costs that would be incurred. Bids are evaluated based upon the lowest combination of bid cost and total lane rental fee.

These bidding techniques, by incorporating road user costs as an element in the low bidder selection criteria, improve the likelihood that work activities are conducted in a manner that minimizes their total cost. For the proper balance to be achieved between the efficiency of performing the work and the needs of motorists; however, it is essential that road user costs be properly estimated.

PROCEDURES FOR ESTIMATING ROAD USER COSTS AT WORK ZONES

Several procedures, both manual and computerized, are available for evaluating the traffic impacts of freeway work zone lane closures. Abrams and Wang[2] in their user

guide on "Planning and Scheduling Work Zone Traffic Control" provide manual procedures for evaluating the impacts of work zones in terms of accidents, vehicle stops and delays, vehicle operating costs, and fuel consumption. The 1985 Highway Capacity Manual [3] provides estimates of work zone capacity and procedures for estimating queue lengths and delays using input-output analysis.

Several publicly available microcomputer programs have capabilities specifically intended for evaluating freeway work zone lane closures. These programs include DELAY (4), FREWAY[5], QUEWZ3-PC[6], and FREQ10PC [7]. Table 1 summarizes their capabilities. Potential applications of these and other models to work zone traffic planning are evaluated in more detail elsewhere.[8,9]

Table 1. Capabilities of Selected Microcomputer Programs for Evaluating Freeway Work Zone Lane Closures

CAPABILITY	DELAY	FREWAY	QUEWZ3-PC	FREQ10PC
Evaluate Alternative Lane Closure Configurations	Yes	Yes	Yes	Yes
Estimate Amount of Traffic Diverting from Freeway	No	No	Limited	Limited
Identify Acceptable Lane Closure Schedules	Not Directly	Not Directly	Yes	Not Directly
Estimate Queue Lengths and Delays	Yes	Yes	Yes	Yes
Estimate Additional Road User Costs	No	No	Yes	No
Evaluate Multiple Freeway Links and Ramp Effects	No	No	Not Directly	Yes

The capabilities of DELAY and FREWAY are limited to evaluating the queuing characteristics of lane closures. DELAY is a LOTUS 1-2-3 spreadsheet that estimates queuing characteristics resulting from lane closures during either maintenance activities or freeway incidents. FREWAY performs capacity analyses for basic freeway segments and delay calculations for work zone lane closures.

QUEWZ3-PC evaluates traffic flows through freeway work zone lane closures and estimates the queue lengths, average speeds, and additional road user costs resulting from alternative closure configurations specified by the user. It can also identify schedules for lane closures so that queuing will not exceed a user-specified queue length in miles or

delay in minutes. These capabilities are particularly useful for planning and scheduling lane closures, which was the specific intent of the development of QUEWZ3-PC. In the class of programs that might be termed work zone lane closure programs (DELAY, FREWAY, and QUEWZ3-PC), QUEWZ3-PC has the broadest range of capabilities.

FREQ is a more general purpose freeway simulation model. One of the latest versions FREQ10PC has been adapted to allow the capacity of freeway subsections to be varied over time, thereby enabling it to evaluate short-term work zone lane closures. (Prior versions of FREQ did not have this capability.) FREQ10PC provides estimates of main-lane and ramp delays, average speeds, exiting volumes, queue lengths, fuel consumption, and vehicle emissions.

For most applications either QUEWZ3-PC or FREQ10PC are likely to be the most appropriate tools for evaluating the traffic impacts of freeway work zone lane closures. QUEWZ3-PC was designed specifically for evaluating freeway work zone lane closures and, therefore, has features and capabilities more directly suited for planning and scheduling purposes. QUEWZ3-PC has the advantage of being the only program that estimates the additional road user costs due to a lane closure. With FREQ10PC, user costs could be computed manually by applying unit cost factors to the delay and fuel consumption estimates that are provided as output. Another unique feature of QUEWZ3-PC is the ability to evaluate all feasible lane closure configurations and to identify the times of day when each configuration could be implemented without producing queue lengths and delays that exceed values specified by the user. With FREQ10PC, this function could be performed by evaluating the results from repeated trials with different lane closure configurations and schedules.

A limitation of QUEWZ3-PC is that it treats the freeway as a single, uniform segment and has no provisions for explicitly considering ramps. With FREQ10PC, on the other hand, the freeway can be represented as a series of segments whose geometry and capacity may be different, and ramps can be modeled explicitly. In many cases, such as when the work zone is between ramps or where ramps are widely spaced and ramp volumes are low relative to main-lane volumes, it is not necessary to consider ramps because their effect would be minor compared to the effect of the lane closure. In those cases, QUEWZ3-PC could be used effectively. When ramp effects are important, however, such as when the work zone spans several ramps and when ramp volumes are relatively high, it may be necessary to use a more general purpose freeway simulation model such as FREQ10PC.

The accuracy of available procedures is limited by our knowledge of two key parameters: (1) the traffic-handling capacity of work zones and (2) diversion characteristics, i.e., when, where, and how much traffic will divert from the freeway to avoid the work zone. At present, however, data on work zone capacity and diversion characteristics are being collected in Texas and Florida and will be incorporated into a new version of QUEWZ3-PC.

SAMPLE APPLICATION OF QUEWZ3-PC

To illustrate the capabilities and limitations of the state-of-the art in estimating the additional road user costs resulting from freeway work zone lane closures, a sample application of QUEWZ3-PC will be presented.

Suppose that a lane closure must be scheduled for a maintenance activity in the outbound direction of a six-lane freeway. The maintenance activity would require six hours to perform if only one lane were closed but could be expedited to four hours if two lanes could be closed. The freeway carries the directional hourly volumes shown in Table 2.

Table 2. Directional Hourly Volumes for Sample Application of QUEWZ3-PC

Military Time (begin - end)	Approach Volume (vph)	Military Time (begin - end)	Approach Volume (vph)
0-1	420	12-13	3,040
1-2	280	13-14	3,100
2-3	290	14-15	3,360
3-4	190	15-16	4,020
4-5	250	16-17	5,450
5-6	620	17-18	5,660
6-7	2,950	18-19	3,390
7-8	5,720	19-20	2,280
8-9	3,640	20-21	1,760
9-10	2,630	21-22	1,720
10-11	2,680	22-23	1,400
11-12	3,120	23-24	800

As a first step, QUEWZ3-PC was used to identify acceptable lane closure schedules. The inputs that are required include the length of the work zone (assumed to be 1 mi), the work zone capacity (2980 vph for 1 lane closed and 1170 for 2 lanes closed), and the definition of excessive delays (20 min or more). QUEWZ3-PC can identify the times of day when each possible lane closure configuration (in this case one of three lanes closed or two of three lanes closed) could be in place without causing excessive delays.

Table 3 summarizes the output from QUEWZ3-PC. For work activity starting at a given hour, the output indicates until which hour work may continue without producing excessive delays. The results indicate that one lane could be closed during any six-hour block between 8:00 a.m. and 4:00 p.m. or between 6:00 p.m. and 7 a.m. However, two lanes could be closed only between 10:00 p.m. and 6:00 a.m. without causing delays exceeding 20 min. If the maintenance activity may be performed only during daylight hours, then these results suggest that only one lane should be closed.

Table 3. Acceptable Lane Closure Schedules for Sample Application of QUEWZ3-PC

For Work Starting at Hour	1 of 3 Lanes May Be Closed Until Hour[1]	2 of 3 Lanes May Be Closed Until Hour[1]
0	8	6
1	8	6
2	8	6
3	8	6
4	8	6
5	8	6
6	8	6
7	8	7
8	16	8
9	16	9
10	16	10
11	16	11
12	16	12
13	16	13
14	16	14
15	16	15
16	17	16
17	18	17
18	7[2]	18
19	7[2]	19
20	7[2]	21
21	7[2]	22
22	7[2]	6[2]
23	7[2]	6[2]

[1] If work continues beyond this hour, the delay through the work zone area will exceed 20 min.

[2] Hour of the day after work started.

The six-hour block 9:00 a.m. to 3:00 p.m. was selected for further evaluation of the closure of one lane. Table 4 summarizes the estimated queue lengths, average speeds, and additional road user costs for each hour of the closure. The estimated total additional road user costs due to the closure are approximately $22,000. For comparison purposes, Table 5 summarizes the impacts of closing two of three lanes for the four-hour block 9:00 a.m. to 1 p.m. The results for closing two lanes indicate that very long queues would result if no traffic is diverted away from the work zone and that the total additional road user costs would be more than $293,000. It would appear, therefore, that the best schedule for the maintenance activity would be to close one lane from 9:00 a.m.

to 3:00 p.m. (In Houston, the Texas State Department of Highways and Public Transportation has performed analyses similar to these and has developed guidelines on when work may be performed and how many lanes may be closed on each freeway.[10]

Table 4. Results from QUEWZ3-PC for Freeway Work Zone Lane Closure in Which 1 of 3 Outbound Lanes is Closed from 9:00 A.M. and 3:00 P.M.

Military Time	Approach Volume (vph)	Capacity (vph)	Approach Speed (mi/h)	Work Zone Speed (mi/h)	Length of Queue (mi)	Additional Road User Costs ($)
9-10	2,630	2,980	53	47	0.0	368
10-11	2,680	2,980	53	46	0.0	392
11-12	3,120	2,980	52	30	0.2	2,375
12-13	3,040	2,980	52	30	0.4	3,644
13-14	3,100	2,980	52	30	0.7	4,849
14-15	3,360	2,980	52	30	1.3	8,258
15-16	4,020	6,000	50	43	0.9	2,212
Total Additional Road User Costs Due to Lane Closure						22,098

Table 5. Results from QUEWZ3-PC for Freeway Work Zone Lane Closure in which 2 OF 3 Outbound Lanes are Closed from 9:00 A.M. and 1:00 P.M.

Military Time	Approach Volume (vph)	Capacity (vph)	Approach Speed (mi/h)	Work Zone Speed (mi/h)	Length of Queue (mi)	Additional Road User Costs ($)
9-10	2,630	1,170	53	30	1.8	11,335
10-11	2,680	1,170	53	30	5.6	31,954
11-12	3,120	1,170	52	30	10.0	56,997
12-13	3,040	1,170	52	30	14.8	83,612
13-14	3,100	6,000	52	30	13.5	69,101
14-15	3,360	6,000	52	30	6.5	34,164
15-16	4,020	6,000	50	37	1.6	6,039
Total Additional Road User Costs Due to Lane Closure						293,202

SUMMARY

This paper argues that freeway work zone lane closures should be scheduled to minimize the total cost of the work activity. Consideration should be given both to the actual cost of performing the work and to the additional road user costs resulting from the lane closure. Several procedures could be used to estimate road user costs. A sample application was presented to illustrate the use of QUEWZ3-PC.

REFERENCES

1. R.D. Ellis, Jr., and Z.J. Herbsman. "The Cost/Time Bidding Concept: An Innovative Approach." Paper No. 890513 Presented at the 69th Annual Meeting of the Transportation Research Board. Washington, DC. January 1990.

2. C.M. Abrams and J.J. Wang. "Planning and Scheduling Work Zone Traffic Control." Implementation Package FHWA-IP-81-6. Washington, DC: Federal Highway Administration, 1981.

3. "Highway Capacity Manual." Special Report 209. Washington, DC: Transportation Research Board. 1985.

4. J. Morales. "Analytical Procedures for Estimating Freeway Traffic Congestion." ITE Journal, Vol. 57, No. 1, 1986, pp. 45-49.

5. N. Rouphail. "FREWAY/SIGNAL." Gainesville, FL: McTRANS Center, University of Florida, 1984.

6. R.A. Krammes, G.L. Ullman, and C.L. Dudek. "User's Manual for QUEWZ3-PC." Report No. 7119-3. Tallahassee, FL: Florida Department of Transportation. 1989.

7. J. Zhang, L. Leiman, and A. May. "Evaluation of Operational Effects of Freeway Reconstruction Activities." Transportation Research Record 1232. 1989. pp. 27-39.

8. R.A. Krammes, G.L. Ullman, and C.L. Dudek. "Microcomputer Analysis Tools to Evaluate the Travel Impacts of Major Highway Reconstruction Projects." Compendium of Technical Papers. Washington, DC: Institute of Transportation Engineers, 1989.

9. R.A. Krammes, G.L. Ullman, G.B. Dresser, and N.R. Davis. "Application of Analysis Tools to Evaluate the Travel Impacts of Highway Reconstruction with Emphasis on Microcomputer Applications." Report No. FHWA-ED-89-023. Washington, DC: Federal Highway Administration, 1989.

10. S.Z. Levine and R.J. Kabat. "Planning and Operation of Urban Highway Work Zones." Transportation Research Record 979. 1984. pp. 1-6.

REAL-TIME TRAFFIC CONTROL AND CHANGEABLE MESSAGE SIGNS

Thomas Hicks
Deputy Chief Engineer-Traffic
State Highway Administration
Maryland Department of Transportation

INTRODUCTION

The opening statement for this paper is similar to that of most any other discussion of work zone safety and how to provide it. That is, the objective of a highway agency is to provide a highway system that is efficient and safe--under all possible circumstances and conditions. The work zone provides a set of circumstances that disrupts the smooth flow of traffic and prevents the highway agency from easily meeting this objective.

Work zones put something different and unexpected in the way of the traveller. When we change the driver's normal and expected way of doing things in the driving task, special steps must be taken to overcome motorists' uncertainties and the expanded reaction times that result.

Several thoughts come readily to mind as ways to offset the adverse effects of work zone traffic control. The most important of these, as the Fundamental Principles of the Manual on Uniform Traffic Control Devices (MUTCD) states, is to provide a work zone scene with roadway geometrics and traffic control devices that are as nearly as possible comparable to those for the normal highway situation. Unfortunately, the extent to which this is possible is often quite small, and this, coupled with the increasing amount of major work done under heavy traffic conditions or at night, has caused us to develop traffic control techniques that readily attract the driver's attention; convey to him useful, timely, and credible information, which, it is hoped, he respects and obeys.

The purpose of this presentation is to discuss one aspect of the effort to control traffic safely in the work zone--for both the public and the highway worker--that being, dealing with real-time traffic control and devices, such as the changeable message sign. While the thoughts expressed may well apply to every type of road system, the comments will generally be directed toward higher speed freeway conditions.

Accidents continue to occur in our work zones and do so at a rate that is too high to accept. Certainly this is especially true for highway workers who can be provided with a vast and impressive array of traffic control measures and devices. Throughout this discussion, it is important to recognize that the thoughts presented deal equally with worker safety and that of the public passing through. Lastly, one telling fact that is worth thinking about is that most of the more severe accidents in work zones involve vehicles leaving the travel lane and entering the buffer area, work space, or other areas along the

roadside. This suggests several things worth exploring, among them, high relative speed, speed too fast for conditions, conditions that are unexpected, improper device usage or application, insufficient notice to approaching traffic, and inadequate attention to the required driving task by the motorist.

In selecting the traffic control strategies in the work zone, another of the MUTCD fundamental principles comes into play--that being the avoiding of overregulation of traffic. The least possible control should be provided with emphasis being given to advising drivers what to expect and letting them drive the work area in a way that is commensurate with conditions and their good judgment. This procedure has been proven effective where uniform, consistent, and realistic traffic control techniques and devices are applied.

To form a sound basis or foundation for the whole traffic control process, we have to understand the human factors that are involved. Drivers like all human beings have a mind-set about a myriad of situations, of which various driving situations are but a few. The thinking process is quite complex, and drivers' actions out on the highway are, more often than not, instinctive reactions that are based upon knowledge stored in the brain from past experiences. The total time to react can vary significantly due to the ease of recognition of the situation, the multiplicity and complexity of the decisions to be made, and the degree to which the situation violates the drivers' expectancies.

In a nutshell, this suggests that our traffic control strategies should be simple ones fulfilling a clear need that use well known devices which attract attention, are well maintained, and are placed to convey information in a way that offers ample time for a safe response or action.

As a final point of introduction, from a legal standpoint, the highway engineer is on sound ground with regard to work zone traffic control when the provisions of MUTCD are followed, particularly those set forth in the fundamental principles, and when procedures are established and followed to monitor and evaluate traffic flow through the work site with changes being made promptly as a result of reviews. Also, while the highway engineer may have the overall responsibility to provide acceptable traffic controls in the work zones, the contractor, law enforcement, and other affected agencies must play an active role in the whole process. Through the better understanding that will result, the process can be carried out more adequately and more expeditiously.

REAL-TIME TRAFFIC CONTROL

What is meant by the term real-time traffic control is giving guidance to the motorist, be it regulatory, warning, or guide information that is current and truthful. In traffic control, credibility is just about everything. What follows is a brief discussion on a variety of traffic control thoughts and elements that will form the basis for work zone traffic control that is "real time" in every sense of the term:

- Traffic control devices (TCD'S) must fit the situation--TCD's must be the appropriate ones for the conditions to be encountered. For the plan to be effective and accepted, TCD's must be up when needed and removed, turned, or covered when not applicable.

- Traffic control devices should be used and applied within a particular work site on the basis of five well-defined work site conditions: highway type, proximity of the work area to the travel lanes, the prevailing speed of traffic, the nature of the work activity, and the duration of the work activity. The number of devices, their size, and placement will vary depending upon the five noted conditions.

- The five basic requirements that every TCD must meet--These five basic requirements for TCD's fulfill a need; command attention; convey a clear, simple meaning; command respect of road users; and give adequate time for proper response. They are so logical they need no explanation. To fail to meet these requirements will render the device useless and seriously degrade the traffic control plan.

- The five ways to ensure that the five basic requirements of TCD's are met--As the MUTCD states, five basic considerations are employed to insure that these requirements are met. They are design, placement, operation, maintenance, and uniformity. Key words here are standardization, simplicity, and consistency. Where traffic control devices and their application have these attributes and they are well maintained, the result is quick recognition and understanding and more accurate and timely response.

- Traffic Regulations--Like control devices, traffic regulations should fulfill a need and be used somewhat sparingly. Usually the minimum control of traffic is to be striven for, advising drivers of what they might encounter and leaving the driving task to them. Regulations should be imposed as needed and promptly removed when no longer needed.

- Contractors' Responsibilities and Duties--Making it work on a real-time basis will require some changes in how contractors are expected and able to respond to various traffic control needs. The following is a listing of subelements of traffic control needs with regard to the contractors' actions and abilities:

  * Specifications that clearly set forth the project traffic control needs and responsibilities.

  * Special provisions that permit quick changes to the traffic control plan in mid-project.

* Method of measurement and basis of payment items that permit quick changes to the traffic control plan (TCP) in midproject.

* Providing of standby and back-up TCD's ready to supplement and/or replace those in the TCP.

* Use of highway agency's TCD stock.

* Frequent routine monitoring and quick action based on observations.

* Establishing agreed to times for taking corrective actions on deficient or malfunctioning TCD's.

* Provisions for "shutting down" a project for nonperformance with regard to the TCP.

* Requirement for training and certification of contractor personnel.

* Specifications for quality devices.

* The logistics and administration within the highway agency to pull it off--a commitment to public and highway worker safety being priority number one.

- Traffic Manager--Every construction project should have a qualified traffic manager in charge of all traffic control items as part of the contractor's work force. For smaller projects, a traffic manager could handle several or be responsible for some, nontraffic tasks, with work zone traffic control being the primary task.

- Law Enforcement--The presence of police in the work site has a positive influence on traffic passing through, and more caution will be displayed by the public. Like other aspects of traffic control, the use of law enforcement officers should be in response to some sort of criteria based upon documented needs.

- Incidents within the Work Zone--Similar to a good traffic systems management program, incidents occurring within work zones should receive prompt attention for quick restoration of normal traffic flow through the area so as to avoid secondary incidents and unwise diversion of highway traffic onto lesser local roads.

- Critique and Evaluation--Assessing the overall performance and effectiveness of an individual work zone traffic control plan is an essential step if the plan is to be responsive to the work site traffic control needs and the overall program is to be an effective one. This serves as a useful learning experience and helps to meld the thinking and actions of the participating agencies.

- Miscellaneous Elements--There are various other traffic control items that crop up from time to time that need attention in consideration of the real-time aspects of traffic control. Among these are the hours of operations, concerns over holiday periods, nighttime operations, prioritization of certain work activities, assessing the traffic control needs within a corridor, special truck and HOV requirements, and research and innovation of new devices and techniques.

CHANGEABLE MESSAGE SIGNS (CMS)

Changeable message signs (CMS) are devices whose use and application are becoming more widespread rather rapidly. The main advantage of the CMS is its ability to display "real-time" (current) information that can be somewhat extensive in its message content. A major disadvantage is the loss of credibility if the CMS information is not true or timely or if it's perceived to be so. The use of CMS requires good communications, quick verification of conditions, and a quick response to message-change needs and needed maintenance.

The following items are those that stand out when considering the use of CMS:

- CMS must always be thought of in terms of being real-time devices, always displaying the most current information.

- CMS supplement other traffic control devices and rarely replace other required devices.

- Despite having the capability of a large amount of message display, CMS must have quite restricted message displays because of the limited viewing and comprehension time of approaching motorists, particularly under heavy traffic or adverse weather conditions.

- CMS, in many instances, may be more effective as an adjunct to nearby Traveller's Advisory Radio (TAR).

- Permanently installed CMS have the following elements of use:

  * Their location is set for reasons other than work zone traffic control.

  * They should be used for work zone traffic control messages whenever possible, regardless of distance.

  * Some sort of flashing light or advance sign is useful for permanent CMS to get the driver's attention.

  * Permanent CMS are usually controlled remotely through some sort of agency traffic control center.

  * Work zone message must vie with nonwork zone messages for space.

  * A two-part message, each part displayed on three lines of copy, on for about 2-3 seconds each with a 0.5-1 second-off period, is about the limit for driver perception and comprehension.

  * An inventory map showing locations of permanent CMS and the routes for which they best apply is useful.

- Portable CMS have the following elements of use:

  * They may be strategically placed relative to the condition about which they are to inform.

  * Their messages should always be work zone related and, when not needed, should be turned off.

  * Portable CMS should not display messages that convey the obvious to passing traffic, but their use should be reserved for areas of major traffic-flow changes or extraordinarily hazardous conditions.

  * Portable CMS in construction areas should be supplied and operated by the contractor under the control of the traffic manager.

  * For each construction project calling for portable CMS, the contractor should have back-up CMS units available in the event of malfunction.

  * Portable CMS maintenance is the responsibility of the contractor; however, the highway agency should have standby maintenance capability in the event the contractor is unable to perform.

  * Like permanent CMS, the portable CMS may be more effectively an adjunct to nearby TAR.

  * Portable CMS may be tied into power and telephone lines for remote operation.

  * Portable CMS, like the permanent type, should be inventoried and their locations noted on a map or listing for remessaging and possible redeployment in the event of traffic control changes or other traffic control needs elsewhere.

  * Portable CMS may be used to advantage as signs giving advance information (in time) to upcoming construction work that will likely cause a significant effect upon the traffic flow.

- CMS Operational Elements--Through experience, some agencies have been able to develop some operational guidelines for CMS use. These include:

  * Warranting criteria along projects having a significant impact on traffic, at work sites having extraordinary conditions, at major traffic flow changes or diversions, and for giving advance information.

  * CMS are particularly helpful where extensive queuing is expected.

  * CMS have some eye-catching characteristics, particularly those of the bulb matrix and fiber-optic types.

  * Portable CMS units are usually not deployed for short-term work duration.

  * CMS placement along freeways should usually allow for two points of exit for major traffic disruptions, with a second CMS unit considered for use closer to the work site.

  * CMS placed for particular hazardous conditions within the work site should be located within a reasonable distance of those conditions.

- Message content:

  * CMS should not display more than two messages within a message cycle.

  * Each message may consist of three lines.

  * All characters within the three lines should be displayed at the same time.

  * A single message should be displayed 2-3 seconds with an "off" interval of 0.5-1 second.

  * If two messages comprise a message cycle, each message should not exceed 2 seconds duration for each message; the second message should follow the first without an "off" interval; and the interval between message cycles should be 0.5-1 second.

  * Each message should convey an individual thought, be brief as possible, and use well-known or logical abbreviations.

    * A library of words and abbreviations should be part of the operations guidelines.

    * A library of approved standard messages should be part of the operations guidelines.

- Maintenance of contractor-owned CMS is by the contractor with agency back-up.
- The highway agency should keep a current and historical log of all CMS locations and messages.
- Only standard and published messages should be used in any CMS without approval from the highway agency.
- Message formulation and approval by the highway agency should be a central office function to ensure uniformity and consistency.
- All portable CMS units should have universal towing hitches, as likewise should all possible tow vehicles.
- A good set of operational guidelines should be developed by the highway agency to cover the use and application of all types of CMS for all purposes.
- CMS messages should always fit the situation and be current.

TRAVELLERS' ADVISORY RADIO (TAR)

Travellers' advisory radio may be the most useful of all of the "real-time" devices in conveying a wealth of useful information to the motoring public about what is going on, where the problem is, how long the situation is expected to last, or when it is expected to occur, and what the motorist might do about it. The TAR operational elements are these:

- TAR's may be permanent or temporary, though the permanent units perform more satisfactorily and with more power.
- The permanent units are powered locally and with telephone connections may be remotely operated.
- The messages should be done with a "professional voice" that is clear and pleasant.
- All messages should be carefully composed and edited.

- Voice synthesizers should be avoided, though automatic composing of prerecorded messages and words is quite efficient.
- Messages should not be longer than 90 seconds, 60 seconds desirable.
- TAR's should always have advance notice signing.
- Use may be made of permanent TAR's and the signs should be supplemented with flashing lights for work zone messages.
- Work zone messages may be combined with nonwork zone messages.
- Message should always be preceded by the name of the agency, the date, and the time.
- TAR's should always be owned and controlled by the highway agency.
- TAR's should always supplement other TCD's and traffic control strategies.
- TAR's operate at 530 AM and 1610 AM and may be in competition with commercial AM broadcasters, in which case, the private sector prevails.
- Leaky cable transmission is superior in voice quality and has significantly fewer problems with commercial radio; however, the range is limited to the highway right-of-way for the length of the cable.

SUMMARY

The State of Maryland has made extensive use of traffic control devices and techniques that provide information and control on a real-time basis and that are credible. This activity has been about equally spread between work zone situations, freeway incident removal, and traffic congestion management. The major devices and techniques used include changeable message signs, travellers' advisory radio, frequent monitoring of key highway sections, use of metro traffic control resources, on-staff State Police liaison, and around-the-clock maintenance capability. Commitment to excellent customer service and to work zone safety to the public and to the highway worker is the highest work zone traffic control priority.

As we develop and expand our own program, we are eager to learn from others, and we intend to conduct research, experiment, and innovate to find more effective ways of reaching our goals.

WORK ZONE SPEED CONTROL PROCEDURES

James Migletz
Jerry L. Graham
Graham-Migletz Enterprises, Inc.

After three years of steady decline in the work zone fatality rate, the Federal Highway Administration (FHWA) reported that an increase occurred in 1988. Fatalities per billion dollars spent for construction increased from 31.9 to 33.2, a 4.1 percent increase.[1] The number of fatalities rose from 701 in 1987 to 756 in 1988, a 7.8 percent increase.

There is a nationwide concern that the work zone traffic safety problem is growing. Many believe that the safety problem in work zones is aggravated by excessive vehicle speeds. Engineers, highway workers, and contractors want and need to know the procedures that can be used effectively to reduce speeds in highway work zones.

This paper describes speeds and procedures for controlling speeds in highway work zones. It focuses on freeways, although many procedures can be applied on other highways and streets as well. Preliminary results of National Cooperative Highway Research Program (NCHRP) Project 3-41, "Procedure for Determining Work Zone Speed Limits," are presented. Vehicle speeds in freeway work zones, measured during the summer of 1990, are presented, as well as results of driver surveys. Speed control procedures and their effectiveness at reducing speeds are reviewed. The paper concludes with recommendations for work zone speed control.

RELATIONSHIP OF SPEED AND ACCIDENTS

Research by Solomon[2] and Cirillo[3] established empirical relationships between travel speed and accidents. The severity of accidents was found to increase as speed increased; fatality rates were highest at high speeds and lowest at about the average speed. Low-speed vehicles also had higher accident involvement rates. More recently, Garber and Gadirau determined that accident rates, on both freeways and arterials, increased as speed variance increased.[4] They also stated that the accident rate does not necessarily increase with an increase in average (mean) speed.

Research by Harkey, Robertson, and Davis[5] found that accident risk was minimized at about 7 mi/h (11 km/h) above the average speed. Tignor and Warren stated that speed limits should be set 5 to 10 mi/h (8 to 16 km/h) above the average speed to reflect correctly maximum safe speed (85 to 95 percentile range).[6] These results are in line with speed zoning practices recommending that speed limits be set at about the 85th percentile speed.

Garber and Gadirau[4] determined that speed variance will be minimized if the posted speed limit is 10 mi/h (16 km/h) lower than the design speed. They also noted that as roadway geometric characteristics improve (by using higher design speeds), drivers tend to go at increasing speeds irrespective of the posted speed limit.

These results[2,3,4,5,6] are for streets and highways without work zones. Intuitively, one would think that work zones with large speed variance accompanied by potential hazards, such as workers in the road, lane closures, narrow lanes, pavement edge drop-offs, etc., would also exhibit high accident rates.

SPEEDS IN WORK ZONES

Research is presently being conducted on speeds in work zones as part of NCHRP Project 3-41.[7] Video cameras were used to record vehicles driving through 50-ft (15-m) "speed traps." Speeds were calculated using the elapsed times through the "speed traps" placed on the open highway upstream of the advance warning signs and in the work area near where work was being done.

Table 1 presents results of a preliminary analysis of speeds on freeways. The open highway average speeds were 65 mi/h (104 km/h) where the speed limit was 65 mi/h (104 kph) and 60 mi/h (96 kph) where the speed limit was 55 mi/h (88 km/h). The speed variance was slightly greater at the higher speed limit. The percentage of drivers driving at the speed limit was also greater at the 65 mi/h (104 km/h) speed limit.

The work-area average speeds were 54 mi/h (86 km/h) in work zones where the open-highway speed limit was 65 mi/h (104 km/h) and 56 mi/h (90 km/h) in work zones where the open-highway speed limit was 55 mi/h (88 km/h). Speeds decreased in the work area, but the speed variance increased from that of the open highway. The work-area speed variance is greater on freeways with 65 mi/h (104 km/h) open-highway speed limits, and the percentage of drivers at the speed limit is slightly less. The greater variance is related to the reduction in work-area speed limit, as described below. The 85th percentile speeds ranged from 5 to 7 mi/h (8- to 11 km/h) above the average speeds.

Table 2 presents preliminary results of work-area speeds based on the amount of reduction in speed limit from the open highway to the work area. In general, the average speed decreases, but the speed variance increases with a greater reduction in speed limit.

The results in Tables 1 and 2 show that work zones with the greater speed variance are those with the greater speed-limit reduction. The greater speed-limit reductions occur on freeways with 65 mi/h (104 km/h) open-highway speed limits.

Research conducted by Richards and Dudek of the Texas Transportation Institute (TTI) recommended maximum reductions in work zone speed limits from 5 to 10 mi/h (8 to 16 km/h) on urban freeways and 5 to 15 mi/h (8 to 24 km/h) on rural freeways.[8,9]

Table 1 - Open Highway and Work Area Speeds on Freeways

	Open Highway				Work Area				
Open Highway Speed Limit (mi/h)	Mean Speed (mi/h)	Speed Variance (mi/h^2)	85th Per. Speed (mi/h)	Drivers at the Speed Limit (%)	Mean Speed (mi/h)	Speed Variance (mi/h^2)	85th Per. Speed (mi/h)	Drivers at the Speed Limit (%)	Number of Sites (n)
65	65	67	70	37	54	104	61	21	9
55	60	56	67	19	56	65	63	26	10
---	62	66	68	28	55	84	62	24	19

1 mi/h = 1.6 km/h

Table 2 - Freeway Work Area Speeds Based on Change in Speed Limit

Change in Speed Limit from Open Highway to Work Area (mp/h)	Work Area Mean Speed	Speed Variance (mi/h^2)	85th Percentile Speed (mi/h)	Number of Sites (n)
0 - 10	57	57	64	11
10 - 15	58	56	64	7
15 - 20	56	85	62	4
20 - 25	54	70	61	4
25 - 30	48	95	57	4

1 mi/h = 1.6 km/h

They also recommended that speed control treatments should be initiated 500 to 1,000 ft (150 to 300 m) upstream of any treatment location within the work zone. The advance distance ensures that drivers have adequate time to react, but that the speed message will still be fresh in their minds when they reach the potential hazard.

DRIVER SURVEYS

A recent study, prepared for John Deere & Co., by Marketing Consultants, Inc., examined how approximately 400 motorists in 4 States view construction zones.[10] The study noted that the current system of alerting motorists to the dangers of driving in work zones is not sufficient to make them change their driving habits unless the driver perceives himself to be in danger. Campaigns should educate the driver that his life is in danger.

Although drivers had a good understanding of sign legends, the study concluded that signs need to be made more specific with more human elements in them. Also, mechanical means should be employed at all construction zones to force drivers to slow down. Signs telling drivers specific speed limits should help as well as telling drivers how close they are to the work area. Ideally, fewer and more consistent signs, carrying a simpler and more specific messages should be created.

Another survey of 58 drivers in 3 work zones in Missouri and Georgia was conducted as part of NCHRP Project 3-41.[7,11] The intent of the survey was to determine if drivers knew they drove through a work zone; could recall the features of a work zone, including the speed limit; and if they really understood the purpose of work zone traffic control.

In one work zone, work was off of the traveled way. In the other two, work was in the traveled way and right lane closures were the traffic control procedures. Almost all of the drivers entering the work zones (91 percent) said they saw the speed-limit sign and/or slowed down as a result of reduced work zone speed limits.

Drivers believe that the speed limit should not be reduced when there is no work or when work is off of the traveled way. Results of speed studies showed that drivers reduced their speeds less when work was off of the traveled way, even though the open-highway speed limit (65 mi/h (104 km/h)) was the same for all three work zones.

The surveys showed that drivers do understand the meaning of work zone signing and traffic controls. Drivers should receive specific messages of speed and distance to the work area. They believe that a lane closure, workers in or near the road, and traffic congestion are reasons to reduce the speed limit.

SPEED CONTROL PROCEDURES

Most highway agencies use regulatory speed limits in work zones to control and enforce vehicle speeds and prevent accidents. However, published research states that regulatory speed limits are not very effective in reducing vehicle speeds in work zones.[12,13,14]

Several other procedures for controlling speeds in work zones have been tried. After reviewing speed control procedures, the Texas Transportation Institute (TTI) studied flagging, law enforcement, changeable message signs, and lane width reduction.[8] The results of the evaluation are summarized in Table 3. The most effective speed control treatments were flagging and enforcement. They had average speed reductions of 19 and 18 percent, respectively. It was determined that a properly trained flagger drawing attention to a regulatory speed-limit sign can reduce vehicle speeds by 5 to 10 mi/h (8 to 16 km/h).

The presence of a police vehicle parked just off of the travel lanes can also reduce vehicle speeds by 5 to 10 mi/h. Speed reductions are slightly greater when the police vehicle's lights and/or radar are turned on.

Work zone speed enforcement also has a positive effect on work zone safety. The Missouri Highway and Transportation Department (MHTD) and Missouri State Highway Patrol (MSHP) have conducted a "Give Yourself A Brake" publicity program and increased speed enforcement efforts in selected freeway work zones.[15] For the year 1989, 369 officers of the MSHP worked over 1,460 hours in the construction zone enforcement program. A total of 1,748 arrests were made; including 1,088 speed arrests.

To evaluate the effectiveness of the program in reducing accidents in work zones, the MSHP compiled work zone accidents for the months of April through September for the years 1988 and 1989. Total accidents for the 2 periods were reduced 15 percent (from 364 in 1988 to 309 in 1989). Fatal, plus injury, accidents were reduced 26 percent (from 104 in 1988 to 77 in 1989). The MSHP believes that the construction-zone speed-enforcement program was successful and continued it in the 1990 construction season.

TTI found that changeable message signs may reduce vehicle speeds in freeway work zones by up to 5 mi/h (8 km/h). Such speed messages, however, tend to lose their effectiveness if displayed for more than a few days at a time.[8]

Narrow lanes can be used in freeway work zones to increase the number of available lanes and, thus, increase capacity. An evaluation in Houston, found that the use of 9.5 ft (2.9 m) lanes in a freeway work zone reduced speeds by 4 to 5 mi/h (6 to 8 km/h).[8] A study by Kemper, Lum, and Tignor found that accident rates increased where 9 ft (2.7 m) lanes were used. Accident rates were reduced to preconstruction levels when 10 and 11 ft (3 and 3.3 m) lanes were used.[16]

Table 3 - Effective Speed Control Procedures[8]

Speed Control Procedure	Average Speed Reduction (%)	Comment
Flagging	19	Innovative flagging--Flagger motioned to slow with freehand, then pointed free hand to speed limit sign. Flaggers on both sides of a travel lane may further reduce speeds. Flagger should be attired with standard vest to connote authority.
Law Enforcement	18	Police traffic controller--Uniformed officer next to speed limit sign and motioning for traffic to slow was the most effective. Stationary police car was also effective, but speeds increased when the officer left the work zone to pursue a speeder. The addition of radar reduced speeds up to 3mi/h. A circulating patrol car was the least effective.
Changeable Message Sign	7	Information message plus speed advisory is effective when used as advanced warning. Most effective for new projects or when traffic controls are changed. Can be effective during both day and night.
Lane width Reduction	7	Narrow lanes reduce speed, but increase speed variance. Minimum lane width should be 10 feet or greater. Devices used to reduce lane width, e.g. cones, can be struck and knocked into lanes of traffic.

Table 4 lists other work zone speed control procedures.[7,8,9,17,18,19,20] Many of the procedures are presently being used and are having some success at reducing vehicle speeds. Depending on local work zone conditions, one of these procedures may produce the desired speed-reduction results.

RECOMMENDATIONS FOR WORK ZONE SPEED CONTROL

The following recommendations for work zone speed control are based on research conducted by Federal, State, and private researchers:

- Design and install work zone traffic controls for the speed that traffic will drive. This was first recommended by the California Department of Transportation in 1972 and has since been repeated by other researchers.

- Using the above recommendation and the results of Garber and Gadirau,[4] the following work zone design speeds based on 85th percentile speed are presented:

Recommend Work Zone Design Speed (1 mi/h = 1.6 km/h)

85th Percentile Speed (mi/h)	Design Speed (mi/h)
60-65	70
50-55	60
40-45	50

- Adhere to established work zone traffic control standards, such as correct taper length and proper number and spacing of signs and channelizing devices.[20]

- Efforts to reduce work zone speed should be founded on an identifiable need.[8] Speed reduction should be aimed at decreasing the number and/or severity of work zone accidents or the potential for accidents at sites where speed-related potential hazards exist. Speed-related potential hazards are those which exist, or are made worse, because traffic is traveling too fast for conditions. Typical examples include:

  * Insufficient sight distance to the work zone, particularly to a lane closure.

  * Hidden or unobvious work zone features, such as subtle changes in alignment and edge of pavement drop-offs.

  * Reduced work zone design speed, that is, the computed speed which is based on such factors as stopping-sight distance degree of curvature.

Table 4 - Other Speed Control Procedures[7,8,9,11,17,18,19,20]

Regulatory and Advisory Signing

Dynamic Speed Limit Signing

Traffic Activated Signing

Truck Mounted Sign

Work Zone Deaths Sign

Radar

Mock-up of a Police Car

Unused Police Cars

Increased Fines for Infractions

Flashing Lights on Signs

High Visibility Clothing

Iowa Weave Section

Rumble Strips

Speed Bumps and Humps

Pacing

Pilot Vehicle

Transverse Striping

Colored or Textured Pavement

Traffic Queue (Congestion)

Highway Advisory Radio

Traffic Signals

* Unprotected work space where an errant vehicle could receive catastrophic damage.

- If a speed limit reduction is needed, reduce the work zone speed limit as little as possible consistent with safe traffic operations.[8,9]

Recommended Maximum Speed Reductions (1 mi/h = 1.6 km/h)

Freeway Type	Maximum Speed Reduction (mi/h)
Rural	5-15
Urban	5-10

- Flagging, police speed enforcement, changeable message signs, and narrow lanes are recommended as the most effective work zone speed control procedures.

- Speed control treatments should be accompanied by a speed-limit sign and a message stating the distance to the treatment (e.g., flagger) or work area.

REFERENCES

1. Bennett, R.C., (1989, December 26), "FY 1989 Annual Work Zone Traffic Safety Summary Report," Report to Regional Federal Highway Administrators, Acting Associate Administrator, Federal Highway Administration, Washington, D.C.

2. Solomon, D., (1964), "Accidents on Main Rural Highways Related to Speed, Driver and Vehicle," Bureau of Public Roads.

3. Cirillo, J.A., (1968, August), "Interstate System Accident Research Study II, Interim Report II," Public Roads, Vol. 35, No. 3.

4. Garber, N.J., and R. Gadirau, (1988, July), "Speed Variance and its Influence on Accidents," AAA Foundation for Traffic Safety, Washington, D.C.

5. Harkey, L., H.D. Robertson, and S.E. Davis, (1990, January), "Assessment of Current Speed Zoning Criteria, "Presented at the 69th Annual Meeting of the Transportation Research Board, Washington, D.C.

6. Tignor, S.C. and D.L. Warren, (1989, June), Speed Zoning in America: Some Preliminary Research Results," Federal Highway Administration, Washington, D.C..

7. Graham-Migletz Enterprises, Inc. and Midwest Research Institute, (1990, December), "Procedure for Determining Work Zone Speed Limits," Unpublished Data, NCHRP Project 3-41, Independence, MO.

8. Richards, S.H., et al, (1985, September), "Improvements and New Concepts for Traffic Control in Work Zones, Volume 4 - Speed Control in Work Zones," Report No. FHWA/RD-85/037, Federal Highway Administration, Washington, D.C..

9. Richards, S.H. and C.L. Dudek, (1986, January), "Implementation of Work Zone Speed Control Measures," Presented at the Annual Meeting of the Transportation Research Board, Washington, D.C..

10. Marketing Consultants, Inc., (1990, April 30), " A Study Concerning Drivers' Attitudes Toward Construction Zones," Prepared for Deere & Company, Moline, Illinois, Elkhart, Indiana.

11. Graham-Migletz Enterprises, Inc. and Midwest Research Institute, (1990, April), "Procedure for Determining Work Zone Speed Limits," Interim Report, NCHRP Project 3-41, Independence, MO.

12. Graham, J.L., R.J. Paulsen, and J.C. Glennon, (1977, June), "Accident and Speed Studies in Construction Zones," Report No. FHWA-RD-77-80, Federal Highway Administration.

13. North Carolina Department of Transportation, "Work Zone Speed Study," Letter to James Migletz dated January 22, 1990.

14. Richards, S.H., M.J.S. Falkner, and C.L. Dudek, (1982, October), "Traffic Management During Freeway Reconstruction and Rural Work Zones," Report No. 263-7F, Texas Transportation Institute, College Station, TX.

15. Fisher, C.E., (1989, December), Letter to James Migletz, Missouri State Highway Patrol, Jefferson City, MO.

16. Kemper, W.J., H.S. Lum, and S.C. Tignor, (1985, January), "The Safety of Narrow Lanes for Traffic Control at Construction Sites," Institute of Transportation Engineers Journal, 10(1), Washington, D.C., pp. 33-38.

17. Ullman, G.L. and D.R. Riesland, (1990, May), "Catalog of Work Zone Speed Control Methods," Research Report 1161-2, Texas Transportation Institute, College Station, TX.

18. Jackels, J. and D. Brannon, (1988, November), "Work Zone Speed Limit Study on Rural I-35 in Minnesota," Minnesota Department of Transportation, Office of Traffic Engineering, St. Paul, MN.

19. Brannon, D., et al., (1990, August), "A Study of Innovative Strategies to Reduce Vehicle Speeds in Work Zones on Rural I-94," Office of Traffic Engineering, Minnesota Department of Transportation, St. Paul, MN.

20. Rouphail, Yang and Fazio, (1988, January) "A Comparative Study of Short-Term Urban Freeway Work Zones," Transportation Research Record No. 1163, Transportation Research Board, Washington, D.C., pp. 4-14.

THE I-95 EXPANSION PROGRAM WORK ZONE TRAFFIC CONTROL

William R. Walsh, P.E.
Area Engineer, I-95 Expansion Program
Florida Department of Transportation

and

Lucy Unsworth
ATE Management and Service Company, Inc.

INTRODUCTION

Over the past 20 years Broward County has been one of the fastest growing communities in the United States. The 1970 population of 620,000 doubled to an estimated 1,256,000 in 1990.

In the middle of the 1980's, the Florida Department of Transportation began an ambitious program of highway improvements to accommodate the growing demand for mobility within the county resulting from this population increase. I-595, a completely new interstate facility serving east-west movements was designed and constructed, and a new north-south link was added at the western edge of the county through the design and construction of I-75 and the Sawgrass Expressway. Even though these new facilities have been added to the highway network, I-95 remains the most heavily traveled route in the county and its expansion is an important element of this improvement program.

I-95 EXPANSION PROGRAM

The I-95 Expansion Program is reconstructing 25 miles of Interstate 95 at a projected cost of approximately $176 million. Before reconstruction, I-95 was a six-lane facility, with auxiliary lanes between selected interchanges. The expansion program is adding concurrent flow HOV lanes and full width shoulders in the median and auxiliary lanes between interchanges. The older sections of I-95 with substandard vertical curves are being totally rebuilt.

In response to the scope and needs of this effort, the Florida Department of Transportation (FDOT) put together a team of consultants with strong credentials in construction management, public information, and maintenance of traffic.

The general consultant, Morrison-Knudsen Engineers, has overall responsibility for monitoring and managing the reconstruction efforts for the DOT. It fulfills these responsibilities with the aid of four construction engineering and inspection (CE&I) subcontractors and through its own experts in the fields of utilities, structures, schedule

analysis, cost and claims analysis, and construction operations.

The Public Information Office (PIO), ATE/Ryder, has handled the tasks of keeping the media informed of construction activities and presenting complex situations in a streamlined form that the media can understand and relay to the public.

The department contracted with the firm of Frederic R. Harris to provide support on maintenance of traffic issues. The activities performed by Harris include: preconstruction planning and assistance with the preparation of special provisions, the review of requests from the contractors for lane closures on the mainline and cross streets, the field surveillance of lane closures and other maintenance of traffic (MOT) aspects of construction, support to the FDOT on incident management issues, and traffic engineering activities related to construction.

Special Provisions

Before the construction contracts were sent out for bids, the consultant team prepared a set of "special provisions" that were made a part of the contract documents. These special provisions provided supplementary instructions to the contractors on many aspects of construction, including the MOT. The MOT items that were included to minimize traffic disruptions are described in the following paragraphs:

- Avoiding conflicts with seasonal peaks--Traffic volumes in the Ft. Lauderdale area increase up to 15% over normal levels between Thanksgiving and Easter when snowbirds and other visitors arrive for their winter vacations. In 3 of the 4 projects, traffic disruptions were limited to just one peak season by using a "fast-track" schedule of 18 months and by prohibiting the contractors from shifting the mainline traffic lanes until after Easter of 1989. The department also decided that it would be better to minimize the overall duration of construction in the corridor by having all 4 of the contracts under construction simultaneously, rather than awarding these contracts sequentially, which would have dragged out the inconveniences of construction for a longer time period.

- Hours of mainline lane closures--Because of the emphasis placed on maintaining traffic flow during construction, several restrictions were placed on the ability of the contractor to close travel lanes. Closures of a travel lane on the mainline were only allowed between 10 p.m. and 6 a.m. This restriction on lane closures required the contractors to perform several of their operations at night, including the reconstruction of the old bridge edge barriers, resurfacing the existing lanes, the installation of new bridge beams, and the pouring of concrete for the new bridge decks.

- Cross-street lane closures--Just as important as the restrictions placed on the contractor's ability to close lanes on the mainline were the lane closure restrictions placed on the 24 streets crossing over and under I-95. These restrictions were

mandated because of the directional nature of travel in Broward County, in which large numbers of people commute between residential communities west of the highway and their jobs, the beach, and other destinations east of the highway. On major cross streets with three lanes in each direction, the special provisions required the contractor to keep two lanes open during peak periods. (On some cross streets which had two lanes in each direction, the department required the construction of a temporary pavement so that the two lane minimum could be maintained when one of the original lanes had to be closed.) Because of the anticipated diversion of traffic from cross streets that were under construction, there was also a restriction which prevented the contractors from simultaneously closing lanes on adjacent cross streets, unless justified by the contractor and approved by the engineer.

- Design speed--Although the highway was to have a posted speed limit of 45 mi/h during construction, the special provisions defined a "design speed" of 55 mi/h for determining the length of tapers in all mainline lane closures and other MOT-related calculations. This proved to be a very effective criterion for achieving a consistently high standard of MOT during construction.

- MOT supervisor--Another mechanism for trying to insure adequacy of the lane closures and other MOT-related items that were set up in the field was the requirement that each contractor identify an MOT supervisor with acceptable experience. In at least one instance the department requested replacement of an MOT supervisor who did not display adequate knowledge of MOT concepts.

- Enhanced guidance--Three of the special provisions were related to providing positive guidance for drivers traveling through the construction area. One of these required the contractor to maintain the visibility of the guide signs. (This was included because of the many tourists and unfamiliar drivers who use I-95.) Prior to construction these signs were, for the most part, located in the median area where the widening for the HOV lanes was taking place or near the outside areas where the auxiliary lanes were being added. Generally the contractors satisfied this provision by temporarily mounting the guide signs in the clear zone outside of the roadway. Another element of enhanced guidance was the extensive use of raised pavement markers (RPM's) that were installed on intermediate layers of the pavement surface. These RPM's were desired because of the monsoon-like rains which occasionally descend upon south Florida, the "open graded mix" nature of these pavement courses which have large surface cavities that absorb most of the paint used for temporary striping, and because the overhead lighting was eliminated by the removal of existing light poles and conduit. For these same reasons, solid lane markings (rather than skip strips) and RPM's at half the normal spacing were used in transition areas where traffic was shifted laterally from one alignment to another.

- Access plan for the temporary concrete barrier wall--The contractor has

performed much of his work behind a temporary concrete barrier wall. This was required for the protection of the motoring public from construction activity, as well as for the protection of the construction crews from the motoring public. Inertial impact attenuators were used extensively at the upstream ends of these barrier wall sections. The access and egress points between the work area on one side of these barriers and the travel lanes on the other side were also carefully considered. The criteria that were used during construction to prevent the improper placement of these openings included: sight distance, curvature, and proximity to nearby exit and entrance ramps. There was also a provision which could be used to restrict the contractor from access to these work areas during peak periods if it adversely affected traffic flow.

- Changeable message signs--The special provisions also mandated the purchase and operation of changeable message signs (CMS) by the contractor. These signs have proven to be extremely effective in alerting drivers to downstream lane closures and ramp closures during nighttime operations, informing them about closures occurring later in the week, and in periodically reminding drivers to control their speeds and be watchful for trucks entering the highway from construction areas beside the travel lanes. They have also been used during major incidents to provide advance warning and route diversion information.

Incident Management

Several sections of the special provisions dealt with incident management during construction. The following items were included to minimize the duration of the delays resulting from these incidents:

- Service patrol--The most visible incident management activity required by the special provisions was the I-95 service patrol. The vehicles in this patrol circulated over the I-95 roadways between 6 a.m. and 7 p.m. Monday through Saturday, helping people involved in accidents, assisting motorists with disabled vehicles, identifying abandoned vehicles, and clearing debris from the roadway. The types of assistance rendered most frequently by the patrol drivers were: moving a vehicle off the roadway, helping people change flat tires, and letting motorists use the cellular telephone to call for assistance from an auto club or a relative.

  The four service patrol vehicles and their drivers were supplied by the contractors that were awarded the major construction projects. The vehicles were light duty tow trucks that could push or tow most automobiles. In addition to the standard equipment found on a tow truck, these vehicles carried water and fuel, equipment and materials for repairing minor breakdowns, a cellular telephone, and a flashing arrow board mounted on top of the cab. Because the service patrol was an integral part of the MOT program, and was incorporated into the contractors construction bid package, the FHWA paid 90 percent of its cost during construction.

- Extensive use of modular glare screen--The department also foresaw a problem of rubbernecking delays created by motorists who pay too much attention to construction and not enough to their driving. This problem was addressed in the special provisions by requiring the contractor to use a modular glare screen between the travel lanes and active areas of construction in the median. When work in the median was completed, this glare screen was relocated to its final position on top of the median barrier wall.

- Accident investigation sites--The construction of accident investigation sites is another part of the MOT program. These sites were intended for use by motorists involved in property-damage-only (PDO) accidents in which the vehicles could still be moved. The accident investigation sites minimize the delay caused by these PDO accidents by creating an area away from the mainline roadway where police officers and motorists involved in an accident can complete their reports and exchange insurance information. Because the sites are largely hidden from the mainline, the capacity reduction caused by these post-accident activities is eliminated.

  The signs for the accident investigation sites now identify them as, "emergency stopping sites." This name change was made to encourage their use by motorists who were having mechanical problems with their vehicles and by police officers issuing citations. The sites are also used by the service patrol drivers who move disabled vehicles there for later recovery by private towing services.

  Because of the large scale of the I-95 Expansion Program, the cost of adding these sites to the roadway has been negligible. In many areas the contractor has been able to provide them as part of his initial construction activities.

- Assistance of the contractor at major incidents--The special provisions also informed the contractor that he would be required to provide assistance in returning the roadway to normal operation after a major incident and that a force account would be available to compensate him for these efforts.

- Freeway incident management (FIM) team meetings--One element of the MOT and incident management program that was implemented prior to the reconstruction of the highway was the formation of the I-95 freeway incident management team. Approximately two years before construction began, the FDOT began chairing a monthly meeting of this FIM team composed of representatives of local police, fire, EMS, and traffic engineering agencies. This team has continued to meet and provides these agencies with periodic updates on significant construction events that are about to occur, as well as fosters the improved coordination of the agencies responding to major incidents on the highway.

Review of MOT Activities During Construction

Most of the elements described in the preceding sections of this paper describe the "do's and don'ts" of the MOT for the expansion program. When reconstruction got under way, the consultant team began the task of monitoring the MOT. This monitoring effort was implemented through three procedures.

MOT Approvals--The contractors were required to obtain approvals for their MOT activities on both a general and detailed level. On the general level, the contractors were required to submit their overall MOT plans signed and sealed by a professional engineer. They were also required to provide a critical path method (CPM) construction schedule, which was to include major MOT activities.

On a more detailed level, the contractors were required to obtain approval for all of their lane closures in advance. This was done so that all of the groups concerned with the MOT would have an opportunity to review the closure plans prior to their implementation. It also provided the necessary lead time for notifying the media, emergency service agencies, school bus dispatchers, and other local organizations. Seven-day advanced approvals were required for all lane closures, and fourteen-day advanced approvals were required for road closures.

Lane Closure Meetings--In most instances the contractor's lane closure requests were reviewed by a committee consisting of the contractor, CE&I, general consultant, MOT consultant, and FDOT. A representative of the Public Information Office also sat in on these meetings so that they would be informed of upcoming events affecting the traveling public.

The primary purpose of these lane closure meetings was to review, as a team, the details of the lane closure plans submitted by the contractors. The lane closure meetings served as a forum for discussing what to do under real world conditions and produced some very creative solutions. One of these solutions featured a "shadow lane closure" on the cross streets to protect vehicles exiting the highway at high speeds.

MOT Field Reviews--The department's MOT consultant, the Frederic R. Harris project staff, reviewed the implementation of these lane closures several times each month and conducted periodic surveillance to identify other MOT items needing improvement. This MOT surveillance frequently disclosed shortcomings that had not been identified by the CE&I's and general consultant. Harris also performed various traffic engineering analyses related to construction, took a leadership role on incident management activities, and provided "quick fix" traffic engineering solutions for traffic congestion problems.

Public Involvement Program

In addition to improving the technical side of traffic control of the work zone, the I-95

program also included a parallel effort in educating and informing the public about the work zone layouts, schedule, and anticipated impacts. They could then be informed while commuting through the work zone and elect to take alternate routes during bottleneck periods. This effort was initiated in the preconstruction phase and will continue through the end of construction.

From the beginning, the Florida DOT carefully planned and created a maintenance of traffic (MOT) plan. To ensure an effective, ongoing communication throughout the project, the DOT also created a multifaceted public information program to keep residents, commuters, businesses, and tourists apprised of the reconstruction and to divert them from I-95 to alternate routes and modes of transportation. The public information effort was funded with State dollars at a cost of $2 million.

As part of the planning process, Florida DOT staff conferred with their counterparts working on major highway projects in other States, and they made site visits to several. Focus groups were conducted with media representatives and local citizen groups. A comprehensive public information plan was produced to guide the program, and a team of public information professionals was hired to operate the program. The I-95 public information program is managed by ATE/Ryder.

Because an advertising budget for the project was cost prohibitive, the strategy was to pursue aggressively proactive media relations so that a constant flow of timely, accurate information about the project was available through the press, radio, and television--in a region that includes three major media markets (Miami, Ft. Lauderdale, Palm Beach). This strategy would be augmented by an active speakers bureau, membership in key business associations, mass distribution of collateral materials, placement of project displays with literature throughout the tri-county area, and operation of a toll-free telephone information service available to residents of the region, as well as travelers throughout the State. Because of the region's demographics, communication materials were produced in English and Spanish, and the project public officers are bilingual.

Given the DOT's balanced transportation strategy, the public information program also would include a marketing initiative aimed at educating people about the emerging system, its elements, and its relationship to the region's economic, social, and environmental well being. When completed, the reconstructed I-95 would feature high occupancy vehicle (HOV) lanes and complementary Park and Ride facilities. To set forth a clear identity, a theme was developed, "I-95 Expansion: Not just a road, a system." Gold Coast Commuter Services was created as the marketing arm with the intent of continuing after the reconstruction was completed.

Construction on mainline I-95 was scheduled to start at three different times during 1989, and the public information program was launched to prepare the community for the work and to minimize the impact once construction was under way. Major elements included the following:

- Production of a five-minute video and numerous slide presentations on the project.

- Production of collateral materials ranging from a master brochure on the entire project to individual "Dear Neighbor" brochures detailing specific segments of work along the reconstruction corridor.

- Production of an I-95 newsletter.

- Operation of the I-95 Public Information Office as a customer service center with interactive exhibits, project literature, consumer information about alternate routes and modes, and free computer matching for car and vanpools.

- Production of the I-95 project portable display units for placement in areas of high pedestrian traffic.

- Production of weekly MOT releases in English and Spanish and periodic special releases on project features.

- Operation of an active Florida DOT I-95 speakers bureau, which features the video and distribution of information packets with brochures, fact sheets, maps, and schedules.

The public information staff established daily contact with beat reporters from the major dailies in the region, as well as electronic media representatives and the traffic reporting services. News conferences were held, as were background briefings and construction site tours. To date the I-95 Expansion Program has received nearly $3 million in free print and electronic media coverage.

RESULTS AND LESSONS LEARNED

There is no clear yardstick for measuring the success of MOT on a project, but here are a few general measures of success. A recent comparison of travel times through the project area during the a.m. peak period revealed no significant difference between runs made before construction began and those made when construction was in full swing. In fact, the use of the barrier wall, glare screens, and other high standard MOT practices has left drivers with the false impression that the roadway is safe to travel at high speeds. It is ironic that the high travel speeds resulting from good MOT practices exacerbate the conflicts with low speed vehicles involved in construction.

There have been few significant complaints from the public. Ordinarily the FDOT would expect to receive many phone calls from citizens critical of construction-related delays or some other aspect of the construction project. Only a small percentage of the phone calls received by the Public Information Office have complained about the MOT on the project. The most significant concerns from the public have been about the

removal of traffic stripes which produced a rumble effect, the pavement lip between lanes during resurfacing, bridge end bumps, and the reduction of speed to 45 mi/h when their perception was that it was safe to drive at higher rates of speed. All of these concerns can be addressed in future reconstruction projects.

The media has remained friendly, or at least neutral. In spite of the overall FDOT budget situation, which was severely criticized by the media in the past, the press has been very helpful in getting word to the public about major activities in advance and did not chastise the project staff when some of these activities resulted in significant delays to the motoring public.

Although a preliminary review indicates that there has been an increase in the number of accidents on the roadway, this is not surprising given the reductions in clear zones and other standards that are necessary as part of the construction process. At this point, however, 15 months after construction commenced, there has been only one lawsuit filed against a construction contractor. Considering Florida's reputation for litigious action, this is a good sign.

Although the CEI's have responsibility for direct supervision of the construction contractor's MOT activities, the main responsibility of the CE&I is to make sure the highway is built according to the plans. Hence, MOT is of secondary importance to these organizations. By having a separate organization concentrating on MOT activities, the department made sure that issues involving MOT got appropriate attention. This system of "checks and balances" for the MOT reviews has provided the department with a viewpoint that is not overshadowed by construction-related concerns. It is a major factor in the successful implementation of MOT on the I-95 Expansion Program.

In hindsight, there were several other items that should have been included in the special provisions. These are: a more stringent requirement for adequately trained personnel performing MOT tasks for the contractor and CE&I, a requirement for the contractor to maintain overhead lighting during construction and to submit an associated highway lighting plan indicating how this would be accomplished, and guidelines on the contractor's use of a "traffic pace" (rolling roadblock) or flagging procedures when work must be performed over the traffic lanes.

One item that has proven to be a definite plus is the retention of separate consultants for periodic review of the MOT and public information. Having a separate PIO responsible for providing adequate advance notice of disruptive events has minimized the number of surprises experienced by the motoring public and residents living near I-95.

WORK ZONE TRAFFIC CONTROL FOR URBAN/SUBURBAN STREETS

Archie C. Burnham, President
Burnham & Associates Consulting Engineers

The urban/suburban environment produces hazardous conditions for those in traffic control work areas. The National Safety Council lists the cause of accidents in the urban work area with the category of garbage collection only a higher risk to governmental employees than work zone activities. Thus, government is impacted, as well as the public and private utilities unless the application of traffic control needs in the work zone area is carried out with maximum efficiency and effectiveness. The complexities of that issue will be discussed this morning along with some observations and recommendations for minimizing error in that environment and to establish principles for fostering maximum efficiency and safety.

One of the complications in the urban work zone area is the presence of multijurisdictional responsibilities. Jurisdictional responsibility is quite different if the operation to be undertaken is on a city street versus a city street that is also a State highway. Complications increase as the number of jurisdictional authorities increase. For example, if a project is developed by local government, it is handled differently by a contractor versus use of their own forces versus use of a permitted utility. All of this is overshadowed if the project is on a State highway and involves State or Federal authorities on the project.

Therefore, in order to assure that work zone traffic control will work properly in the urban/suburban environment, additional complexities must be recognized, identified, and addressed with appropriate regulation in an organized fashion. Failure to accomplish this is to ignore basic premises that are correctable with attention. In a day sensitive to tort liability, it behooves all concerned to become familiar with these principles to assure the best operation that is possible in the urban work zone environment.

SIGNIFICANT PROGRAMS THAT ADDRESS THE PROBLEM

In the next few moments I would like to take an opportunity to discuss those organized programs that others have put in place to address consistency and professionalism in the urban/suburban traffic control area. Foremost in recognition is the American Traffic Safety Services Association (ATSSA) program, which has been piloted to be made available on a national basis. This course embodies a three-day training period that specializes in the techniques of traffic control in work zone activities in general and results in recognition of the successful student through the award of a certification process valid for two years. Other States or organizations have followed this lead by customizing specific applications to other areas. In my State for example, the

Georgia Safety Council has endeavored to produce a two-day course and certify its graduates. This course is based directly on the Georgia Specifications for traffic control, established by Georgia D.O.T. This program was developed during 1990 and is already under consideration for modification to fit the requirements in other States and to be presented locally to city and county governments.

Some States have customized in-house training to provide specific orientation for their own employees. The State of Utah has undertaken such a program and, on a periodic basis of one to two times a year, gathers their affected personnel for instruction in this particular area. The advantages of in-house instruction are obvious because in a controlled environment, one may single out those problem areas that are of most concern and dwell with emphasis on that correction.

Users

The contracting personnel have been the main beneficiaries of private programs, such as those run by ATSSA and the Georgia Safety Council. However, a prime need for this training is addressed to private utility companies and local governments in the urban environment. Many times the urban environment is not large enough to support in-house training and must focus its attention on other providers of such service. This is due to budget accommodations, but also importantly, to an understanding of need as associated with risk. Even today, many smaller local governments do not fully appreciate the amount of risk involved in the exposure of improper traffic control in the highway environment.

Certification

There is a significant benefit from certifying graduates of such a training course. Such certification, first of all, serves as a separator to eliminate those personnel with insufficient training, experience, and knowledge from being responsible for traffic control projects. This is accomplished by providing comprehensive testing which is evaluated in conjunction with work history before awarding certification status to a graduate. Because certification is related to on-the-job experience, recertification is necessary on a periodic basis. Then those whose job responsibilities change or who lack familiarity with changing standards because they do not keep current can be separated from the certification program. Recertification also offers the opportunity to double check the status of an individual who may have errantly slipped through the process of certification the first time.

Training Content

The subjects for discussion that should be included in a training course of this nature are quite voluminous. The Table of Contents from the Georgia Safety Council Work Zone Training Course is shown in Figure 1. You will note that this training course emphasizes the specific manuals and specifications required on the job, as well as explains

Table of Contents

Figure 1 - Table of Contents from the Georgia Safety Council Work Zone Training Course.

basic traffic control devices and certain traffic control strategies. This course is a hands-on opportunity for the student to work out classroom problems in a group so that other members of the group may support the leader in discerning the nature of the problem and proposing appropriate solutions. The options are reviewed with the class, and alternatives are brought forth to indicate a wide range of possibilities available in problem solution. This method of training allows full discussion and exploration of practical problems.

REQUIREMENTS

To set the requirements for work zone traffic control, a jurisdiction needs to comply both with national and State standards. Once the standards are identified, there is a need to verify compliance. These inspection checks are follow-ups that are an essential part of assuring maximum compliance with known principles.

STANDARDS FOR APPLICATION IN URBAN/SUBURBAN WORK ZONE TRAFFIC CONTROL AREAS--MUTCD, PART VI

The Manual on Uniform Traffic Control Devices (MUTCD) has an entire section devoted to the subject of construction and work zone traffic control. While this section does not exclusively address the need for urban and suburban areas, it does provide a minimum foundation structure that is applicable to the urban areas, as well as others. The MUTCD states that problems of traffic control, which occur when traffic must be moved through or around road and street construction, maintenance, operation, and utility work, produce incidents on or adjacent to the roadway. Because there is no one standard sequence of signs or other traffic control device that can be set up for all situations due to the variety of conditions encountered, it is thus mandatory that basic principles be established. These techniques produce the successful application of traffic control devices in urban/suburban work areas. The MUTCD establishes principles to be observed in the design, installation, and maintenance of traffic control devices and prescribes standards where possible. The intent of the MUTCD is to provide safe and expeditious movement of traffic through the work area and to accommodate the safety of the work force performing the operation.

Principal Concerns

There are four principal controls that pertain to the standards to be established. These are:

- The speed of the traffic.
- The volume of the traffic.

- The duration of the operation.

- The exposure to hazard.

Urban/suburban conditions generally are thought to be dealing with low speeds and a wide range of volumes. Specific problems include limited maneuver space, frequent turns, crossing movements, significant pedestrian activity, and other impediments. The kind of work activities usually found in urban/suburban work sites include pavement cuts for utility work, patching and surfacing of the pavement, pavement marking renewals, encroachments by adjacent building construction, and work conducted simultaneously with the continued operation of various commercial and residential activities. Provisions must be made in urban/suburban areas to accommodate frequent need for response to fires, accidents, stalled vehicles, fallen power lines, and other activities. Sometimes weather, lighting, and traffic conditions make the conduct of these activities especially tricky.

Responsibility

The government body having jurisdiction over the project assumes the responsibility for design, placement, operation, and maintenance of traffic control devices. This responsibility is often delegated to others through contracts, and under those conditions, the contractor is obligated to follow the same standards and requirements established by the governmental body. Sometimes contractual documents elaborate on these standards by providing official instructions and special provisions or by incorporating specifications associated with the work.

Five Fundamentals

The MUTCD stipulates five specific principles that are fundamental to the proper control of traffic in construction and maintenance work areas. These principles are summarized as follows:

- Traffic safety in the work zone should be a high priority element from planning through design and construction.

- Traffic movements through the project should be inhibited from normally expected traffic flow patterns as little and as infrequently as possible.

- Continuous guidance should be provided through the use of clear and positive traffic control devices.

- Traffic control devices and strategy should be monitored by inspection and review regularly.

- Appropriate maintenance must be performed at the work zone site to assure effective display of appropriate traffic control devices.

OTHER MATERIALS AND PUBLICATIONS

The Georgia Safety Council, ATSSA, and certain States have developed training courses that highlight these standards and basic principles. The objectives of the course are to focus a high priority on traffic control and safety on urban and suburban streets. To properly emphasize those needs in the urban/suburban element, the courses address the presence of numerous factors. These include driveways, closely spaced cross streets, vehicle parking, pedestrians, frequent turns, traffic signal impacts, narrow roadway, public transit, utility needs, congested conditions, conflicts with private construction, and the need to maintain access to commercial businesses and private residences. Various handbooks published by utility companies, urban governments, and others have assembled a great deal of useful information on this subject. A listing of popular handbooks and the address and availability is listed in Figure 2.

The Transportation Research Board is developing a synthesis report on this subject titled "Work Zone Traffic Control & Safety on Urban & Suburban Streets." The publication is scheduled for release in early 1991 and captures many of the practical activities necessary to make the application of traffic control devices in urban work areas more effective. This publication includes five chapters discussing the fundamental aspects of traffic control needs in work areas and includes in the appendix, model standards, policies, and manuals that have been drafted to be applicable to the urban/suburban work environment.

COMMON AREAS OF MISUNDERSTANDING

A review of the existing practices in this country dealing with traffic control needs in urban work zones indicates a violation of certain fundamental principles most commonly associated with the work. A review of these principle shortcomings is summarized as follows:

Preplanning Activities

Most work projects suffer from the disadvantage of not having appropriate personnel review and discuss the needs of traffic control on the project before the project is initiated. This preplanning effort allows anticipation of obvious pitfalls that can be encountered and sets up provisions to address these problems before they occur. There are nine steps identified in the process of selecting preferred alternatives in work zone traffic control that are taken from the Federal Highway Administration "Notebook on Design and Operation of Work Zone Traffic Control." See Figure 3.

STATE GOVERNMENTS:

Handbook of Traffic Control
for Routine Maint. Ops.
Oklahoma D.O.T.
2000 North East 21st Street
Oklahoma City, OK 73105-3204

Traffic Barricade Manual
Arizona D.O.T.
206 South 17th Street
Phoenix, AZ 85007

Pennsylvania D.O.T.
P.O. Box 2028
Harrisburg, PA 17120

Nebraska D.O.T.
WATCH
Wrk Ar. Art. Ctrl. Hnkbk.
Traffic Engineering Div.
Omaha, NE

North Carolina D.O.T.
P.O. Box 25201
Raleigh, NC 27611-5201

Nebraska Dept. of Roads
Traffic Engineering Div.
Lincoln, NE 68509

UTILITIES

Work Site Protection Manual
Illinois D.O.T.
Springfield, IL

Work Site Traffic Control
Southern Bell Telephone Co.
1155 Peachtree St., N.E.
Atlanta, GA 30367-6000

Penn Power & Light Co.
Work Area Traffic Control
Safety and Health Dept.
Harrisburg, PA 17102

Traffic Control for
Const. & Maint. Work
Dept. of Public Works
Milwaukee, WI

LOCAL GOVERNMENTS

Topeka Kansas
City Traffic Engineering Dept.
Topeka, KS 66303

Edenborough, IL
Bureau of Traffic
2300 S. Dirksen Pkwy.
Springfield, IL 62764

Traffic Control Handbook
City Traffic Engineering Dept.
Overland Park, KS

Traffic Control for Const.
and Maint. Work
Dept. of Public Works
Milwaukee, WI

Adm. Guide for MUTCD in
Constr. & Maint. Oprs.
Traffic Engr. Div.
1741 S. Jefferson Ave.
Saginaw, MI 48601

FEDERAL GOVERNMENT

U.S. Department of Transportation
Federal Highway Administration
Washington, D.C.

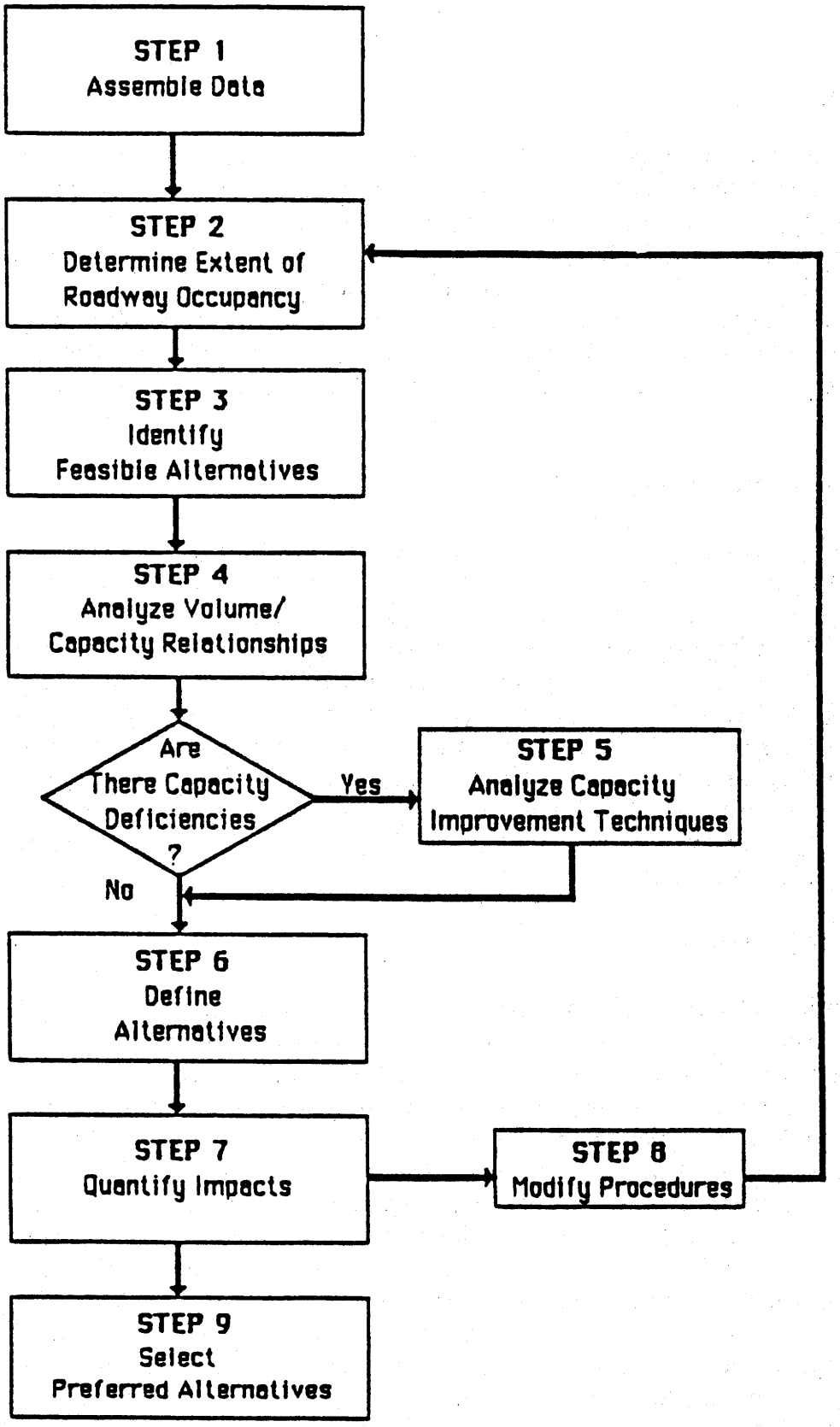
Design & Operation of Work Zone
Traffic Control - Training Course
Participant Notebook
U.S. Government Printing Office

Manual of Uniform Traffic Control
Devices for Streets and Highways

ATSSA

Traffic Control in Urban &
Utility Work Areas
5440 Jefferson Davis Hwy.
Fredericksburg, VA 22401

Figure 2 - Listing of popular handbooks and addresses.



(Taken from FHWA notebook - Design & Operation of Work Zone Traffic Control)

Figure 3 - The Planning Process

Planning Stage

One of the key activities in the planning area is to appreciate various alternatives that can be utilized. For example, activities such as storing extra sign and marking material on the trucks can prove invaluable should a maintenance problem or accident destroy a traffic control device. It, thus, can be replaced quickly and effectively without compromise to the traffic control plan, thus avoiding having to wait for another day to go back and then replace the device. This would not occur if in the planning process provision is made for the allocation of extra materials for resupply. There are many other activities that a walk-through of on-the-job activity would uncover in a preplanning activity.

Adequate Information on Site

The project personnel should have in their possession appropriate handbook materials to assist them in the execution of their given activity in traffic control. The urban environment can be accommodated with typical diagrams so personnel who place barricades, paving markings, or flashing beacons can be alerted to some type of training for the job and reminded with printed information that they keep on their person or in their vehicle. This also addresses the common area that, too many times, unqualified personnel are assigned to the work traffic control area who have not been trained in areas of flagging or installation of traffic control devices. Such training booklets would illustrate, for example, the proper sequencing for the display of the device, as well as the proper sequence for the removal of the device; both of which can be directly detrimental to safety if not incorporated properly.

Knowledge of Devices

A principal violation in the urban work zone is to assign personnel to the site who do not understand the function and application of various traffic control devices. Distinctions need to be made in what is to be accomplished by a flashing beacon versus a steady-burn beacon. Likewise, workers need to be acquainted with motorist needs in having traffic control devices placed consistently in practical locations that will not violate driver expectancy. This involves proper spacing both laterally and horizontally, spacing between the devices themselves, as well as spacing in the road environment along the roadway. There must be a clear definition of the appropriateness of spacing controls in the road versus those placed appropriately along the road. In the urban/suburban environment, these same fundamentals must be accommodated in the midst of pedestrian activity, handicap ramps, commercial driveways, and other specific conditions. Vast knowledge of the traffic control device and its normal application are fundamental principles often violated due to the complexity of the urban environment. These can be overcome with proper training, supervision, inspection, and maintenance.

Set Time Uses

Urban activity only disturbs normal traffic flow for a certain duration of time. Many workers unfortunately misunderstand this criteria as a reason not to fully utilize the protections for the work site by the use of traffic control devices. This is really foolish when one considers that it is only an instant of time when the right combination of traffic and traffic conditions occur to create an error that produces accidents. This probability of occurrence is greatly magnified if in fact the urban environment is ignored for traffic control devices because the duration of the work activity is thought to be short. Even if the work activity is short, such as stopping to check a manhole or clean out a drop inlet, the need to properly regulate traffic flow by establishing a transition and giving notice of the work activity, is paramount to safe traffic operations. Needless to say, many of these activities that are envisioned to be short term actually become extended due to the complication of the work. Their extension greatly multiplies the exposure risk to hazard when appropriate traffic control has not been implemented for the work activity.

Special Conditions

Frequently the work activity in an urban or suburban activity must be conducted without sufficient space to erect traffic control devices due to the nature of the urban environment with short blocks, restricted right-of-way, and other conditions. These conditions call for creative applications of traffic control device principles and may incorporate prior notice of the activity by way of signs or media notice. These are means for increasing awareness of the activity before motorists approach the work site itself. Sometimes it is necessary to acquire additional work space by the temporary closure of driveways, rerouting of pedestrian activities, or the elimination of certain turning movements in the traffic stream. These generally require coordination and liaison with others to effect their implementation.

Enforcement

Compliance with traffic control devices on a work zone activity in urban/suburban areas is no different than the problem of compliance on other work projects. However, the availability and support of local law enforcement can often be more cooperative in an urban/suburban environment. This cooperation can extend to the realism of effective speed limit enforcement, as well as citations for violation of certain traffic control devices or patterns. Often the mere presence of a police vehicle in the vicinity of the work area causes a significant change in the driving habits of the motorist. This is often ignored. The effective deployment of enforcement is a viable tool to be included in consideration of needed traffic controls in the urban/suburban work zone environment.

Tapers

Almost every work site involves the application of either a merge or a channelization taper on the project. These tapers will not effectively accomplish traffic control unless

they are established in the proper length. They also must be confirmed with the appropriate number of channelizing devices, and they should be installed and removed in the proper sequence. While there are appropriate taper formulas, too often work zone employees tend to use judgment of how to eyeball the taper on the project. This avoids the protection that is afforded by using the tapers, which are simple to calculate and easy to understand if one has taken the time to become knowledgeable of the principles and understanding in the uses of the devices.

Flagging

Most projects do provide a flag person to advise the motorist of stop-and-go conditions as some part of the project. However, all too often the personnel are untrained and undisciplined. These personnel must be trained with sufficient background to understand what is effective in communicating to the public and what is not. The work zone traffic supervisor must make some effort to institute a spot check on flagging personnel to assure that these standards are carried out if the work zone traffic control is to be effective.

SUMMARY

Present attention to work zone traffic control in urban/suburban areas leaves much to be desired. Until recently, there have been no credible efforts made to provide training, handbooks, policies, and standards that take into account the special problems of the work site in urban environments. However, training courses offered by the ATSSA, the Georgia Safety Council, and several cities and States have recognized the problem and are providing creditable helps. A Transportation Research Board publication to be released in early 1991 should be of further assistance as a collection of what's available and what's important in the subject area of work zone traffic control in urban and suburban areas. Ultimately, those in charge of traffic control devices on the work site must become increasingly accountable to assure that fundamental principles are placed into effect. This is accomplished with training and experience as stipulated by the principles and standards discussed within this paper.

PROTECTING PEDESTRIANS IN WORK ZONES: ROLE FOR THE MUTCD

Errol C. Noel, Ph.D., P.E.
Associate Professor of Civil Engineering
Department of Civil Engineering
Howard University

The right of pedestrians to enjoy safe access to property abutting work areas and clearly defined pathways through, around, and under diverse types of work projects is no less important than the right accorded to motorists. Part VI of the 1988 edition of the Manual on Uniform Traffic Control Devices (MUTCD)[1], although still evolving, is evidence of progress in motorists' safety in work zones accomplished over the past two decades. Although held in high regard as the national standard, the MUTCD is grossly deficient in pedestrian safety standards for work zones. In response to this deficiency, only a few States and cities have included supplementary material on pedestrian safety in the work zone section of their own MUTCD's. In general, the quality of information on pedestrian safety in State manuals is as limited as that of the Federal MUTCD.

A recent report[3] of the Federal Highway Administration (FHWA), which involved observation of pedestrian safety practices in several large cities, clearly indicates that problems identified in the early 1980's[4,5,6,7,8] still exist today. In part, this paper draws from that report and information collected during field observations and discussion with city officials in Seattle, San Francisco, New York, Philadelphia, Washington, D.C., Richmond, Chicago, Atlanta and Baltimore. Observed deficiencies in pedestrian safety practices include undelineated work areas; undefined pedestrian pathways; use of 6-ft opaque fences at intersections without provisions for good visibility at corners; insufficiently defined pathways; wide variation in the size, message, and placement of signs among the cities, within cities and within projects; use of pathways which lead pedestrians into vehicle travel lanes in the middle of city blocks; use of disconnected concrete barriers to protect pedestrians; lack of concern for the quality of surface for temporary pathways; an unawareness of the need to protect pedestrians from all overhead work within the public right-of-way; use of an uncoordinated system of contract letting which does not ensure review by officials with sound knowledge of pedestrian needs in work areas; no locally adopted standard for pedestrian safety in work areas; a general reliance on the Federal MUTCD, in spite of its drawbacks; hesitance in adopting the guidelines provided by the Traffic Control Device Handbook (TCDH)[2] because it is not a national standard; and lack of active enforcement programs to promote compliance to the already marginal pedestrian safety requirements.

In spite of the deficiencies mentioned above, examples of prudent practices in pedestrian safety and control in work zones were observed in some cities. These examples tend to represent the exceptionally high-profile projects and are generally sporadic. New York City, Chicago, and Philadelphia, for example, require contractors to

submit traffic control plans, in scale or schematic, for approval before the issuance of building permits. While this is a good idea, the lack of an effective enforcement program has enabled contractors in some cities to avoid installing required traffic control measures. Some States include general statements on highway construction and traffic control plans regarding the need for safe passage for pedestrians. However, details on the pedestrian control procedures and applicable standards are avoided: satisfying the project engineer on large State projects is often the criterion for approval of planned pedestrian safety measures.

State and local building codes have had a positive effect in protecting pedestrians from the overhead danger posed by building construction. However, there is no uniform approach to pedestrian protection during overhead short-term maintenance activities on these same buildings. Use of a mobile canopy, observed on a single window-washing activity in downtown Philadelphia, might be an idea whose time has come. Greensboro, North Carolina includes several paragraphs on pedestrian traffic control principles and references section of the North Carolina State Building Codes in its Work Area Traffic Control Handbook (WATCH).

Seattle's Traffic Control Manual for In-Street Work uses many of the fundamental principles of the TCDH and provides information on pathway surface, signage, accommodation of the handicapped, and illustrations on the use of fences, barricades, and canopies for pedestrian protection. San Francisco implements a coordinated effort involving State and local traffic engineers, local police, and contractors for major construction -- subways, skyscrapers and transit guideway rehabilitation--in the city. Meetings are also held to discuss and resolve traffic safety problems. Illinois is one of the few States which has included typical drawings for corner, crosswalk, and midblock closures of pedestrian pathways in its MUTCD.

The above discussion does not reflect the total practice in any locality, but it does indicate that some State and local officials have recognized the need for explicit guidelines on pedestrian measures for work zones and have attempted to do something about it. The poor state-of-the-practice in protecting and controlling pedestrian traffic in work areas can be blamed, in part, on the unavailability of comprehensive local and national standards, the fact that many types of work within the public right-of-way escape the scrutiny of traffic engineers, lack of effective enforcement, a general unawareness on the part of traffic safety officials, contractors and utility workers about the varied characteristics of the pedestrian community, and, finally, the lack of training in pedestrian safety in work areas.

Since there is a tendency of States and localities to adopt the minimum standards of the MUTCD, improvement of Part VI of the MUTCD has the greatest potential for improving the state-of-the practice. Although sporadic in nature, an information base on prudent practices already exists, including the TCDH. Improved standards for the Federal MUTCD should reflect the range of work activities which pose danger to pedestrians within public right-of-ways. Protecting pedestrian from overhead work activity

in downtown areas should not be excluded. Any revision of the MUTCD to expand its coverage of pedestrian and worker protection in work zones should be explicit about the types and usage of specific traffic control and protective devices, i.e. the use of barriers, barricades, drums, signs, cones, tapes, fences, canopies etc. Reference No. 3 may be consulted for more information on potential areas for improvement in the MUTCD. The net product of a comprehensive revision must be a Federal MUTCD that officials of the States and localities can proudly reference in design and traffic control plans and use as a basis for enforcement. Of course, there will also be the need for research to resolve several issues regarding the appropriateness of some current practices, for example, the use of warning, regulatory, and construction signs, and pedestrian protection devices.

Although improvements in the Federal MUTCD to include material on pedestrian safety in work zones is highly recommended, it would be wishful thinking to believe that this action by itself would solve all current problems. Surely, some of the past excuses about an available Federal standards would be eliminated. Major improvements in the state-of-the-practice, however, would require the training of officials--traffic engineers, inspectors, and the police--on approved practices, the installation of a system for ensuring that all projects which could threaten pedestrian safety in the public right-of-way do not escape the review of traffic control procedures before permits are granted, and an organized and continuing inspection program with the capability for on-the-spot citation for safety violations. No doubt, funding for supporting the additional cost for pedestrian safety management could be substantial, especially among agencies which have no on-going aggressive program. Motivated by a number of lawsuits relating to contractors' negligence in deploying proper pedestrian control devices, one large Midwestern city has increased its construction permit and public space access fees in order to generate funds for hiring and training safety inspectors in work zone traffic control. An additional source for funds is fines for violating local work zone traffic control standards.

REFERENCES

1. U.S. Department of Transportation, Manual On Uniform Traffic Control Devices for Streets and Highways, Federal Highway Administration, Washington, D.C., 1988.

2. U.S. Department of Transportation, Traffic Control Device Handbook, Federal Highway Administration, Washington, DC, 1983.

3. Noel, Errol C., Sabra, Ziad A. and Dudek, Conrad L. Work Zone Traffic Management Synthesis: Work Zone Pedestrian Protection, Report No. FHWA-TS-89-035, Federal Highway Administration, Washington, DC, July 1989.

4. Chadda, Himmat S. and McGee, Hugh W., "Pedestrian Consideration in Highway Work Zones," ITE Journal Vol. 54 No. 9, Institute of Transportation Engineers, Washington, DC, September, 1984.

5. Chadda, Himmat S. and McGee, Hugh W., "Pedestrian Safety Through Work Zones: Guidelines," ASCE Journal of Transportation Engineering Vol. 109 No. 6, American Society of Civil Engineers, New York, November, 1984.

6. Chadda, Himmat S. and Brisbin G.H., "The Obstacle Course: Pedestrians in Highway Work Zones," Transportation Research Record No. 904, Transportation Research Board, Washington, DC, 1983.

7. Chadda, Himmat S., McGee, Hugh W. and Ligon, Claude M., "Pedestrian Accommodation in Highway Work Zones," Traffic Quarterly Vol. 36, No. 3, Eno Foundation for Transportation, Connecticut, July, 1982.

8. Chadda, Himmat S., Ligon Claude M. and McGee, Hugh W., Improved Pedestrian Control in Highway Work Zones, Report No. FHWA/RD/009, Federal Highway Administration, Washington, D.C., November, 1981.

FROM NO-CONES TO NO-ACCIDENTS

Rick Maddux
Safety & Training Coordinator
Cedar Falls Utilities

For the year 1989, 782 people were killed in or near traffic work zones. Seventy-five percent of these people were in the public sector. Think about it, that is 200 of our employees. Two hundred people, that's how many people we have in attendance here today.

Three years ago I attended a training seminar on traffic control in the work zones, and at the time, I was relatively new on the job and had my hands full just trying to learn what our lineman do and how in the world they climb those poles.

First, let me tell you a little about Cedar Falls Utilities (CFU). We are a municipal utility company. We serve about 14,000 customers and employ 135 people. We generate and distribute electricity. We also distribute gas and water.

Because we are in the utility business, our employees are not in one spot too long. They are usually there for only a couple of hours, depending upon their work assignments. My presentation will be directed more towards the short duration, or the quick hits, as we call them.

We will start with the new or part-time employee. When we bring in new hires, we put them through our orientation program, which is outlined in Figure 1. We discuss first aid, safety shoes, safety glasses, and proper clothing, including reflectorized safety vests. We show them the location of fire extinguishers and how to use them. We issue hard hats, gloves, and, if necessary, keys. We issue safety manuals and review the general section and discuss the "Right to Know" law.

As you see, traffic control is an important part of our orientation. The vest became a part of our personal protective equipment (PPE) as a partial result of the changing of the OSHA standard that became a regulation in 1980 (1926.651), which states: "When exposed to vehicular traffic, employees shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material."

You will note in some of our slides that sometimes our employees are not wearing vests. Wearing a synthetic vest in certain instances could cause more personal injury potential than protection benefits. In the event that there might be a flash or an explosion, this material could adhere to the skin and have to be surgically removed. We have since found a flame retardant, dielectric, and inexpensive vest. We hope they are now in regular use.

Each new employee who will be flagging is given a flagger handbook and is allowed time to read it. We give them approximately 20 minutes to read it and then show them a flagger's

Today's Date _____

Name of Employee _____

ORIENTATION PROGRAM FOR NEW EMPLOYEES

I. INTRODUCTION

A. **First Aid**
1. Location of first aid kits.
2. Emergency use of radio.
3. Transportation of injured.
4. Accident/injury reports.
5. Vehicle accident reports.

B. **Keys** (if necessary)

C. **Locker Assignment**

D. **Fire Extinguishers**
1. Operations.
2. Locations.
3. Evacuation and central meeting place.

II. PERSONAL PROTECTIVE EQUIPMENT

A. **Safety Shoes**
1. Steel-toed (mandatory).
2. Allotment for safety shoes.

B. **Hard Hats**
1. New issue.
2. Replaced every 3-5 years.
3. Class A & B rating

C. **Safety Glasses**
1. Prescription policy.
2. Issue of non-prescription sunglasses.
3. Advise employee of variable tint glasses.

D. **Gloves**

E. **Clothes**
1. Preference of cotton clothing.
2. Policy on proper clothing.
3. Rain Gear.
4. Company uniforms.
5. Safety Vest

Figure 1 - Orientation program for new employees.

III. EMPLOYEE SAFETY MANUAL

A. **General Section**
   1. Operation of vehicles.
   2. Seat belt requirements.
   3. Housekeeping.

B. **Review Specific Work Area**
   1. Traffic control in work zone (if applicable).
   2. Issue flaggers handbook.

IV. RIGHT TO KNOW LAW

A. **Advise of Right to Know**
   1. Location of MSDS's.
   2. How to read MSDS.
   3. Labeling of containers.

Employee Signature _____

Figure 1 - Orientaion program for new employees. (continued)

video provided by the Iowa Department of Transportation. They are then issued their personal protective equipment and taken to the job site. A supervisory check is done to insure that the traffic is responding to the signs and our flaggers.

Because CFU is a municipal utility, we must be conservative when we purchase protective equipment. We take bids and are constantly comparing prices. Traffic control signs are expensive. Our general manager, however, said that we need to protect our employees and the public. There was no need to budget these items for 1991, and we were given the authority to address this problem as soon as possible.

We first had to determine what we needed--who needed signs and what size they needed to be. We then had to consider the size and the weight and if we could carry them on our trucks. We also needed to decide when they would be used and how the sign should read. We felt that our Water and Gas Department did not have a need for the 48-in signs, because there were not any gas mains or water lines in the 55-mi/h plus zones. We then decided that the 36-in signs would be sufficient. Also, our crews will be working at night; therefore, the signs should be reflectorized. The signs must be portable and we need at least six signs for each of our crews. Since then, we have ordered more signs with different wording on them that apply to specific tasks. The signs must also be universal so that we can change them according to the work being done. In the event that there is a need to use the 48-in signs, we do have them available through our Electric Distribution Department.

Don't get me wrong. This is not a plug for any specific company. We looked at three different types of signs, and the flexible signs fit our needs and were also the least expensive at that time. With our Electric Distribution Department, we decided that with power lines being on highways and rural roads, we needed 48-in signs. Again, the signs must be reflectorized for the possibility of nighttime use, they should be of light weight for the I-have-a-sore-back-employee, and portable and readily available for the I-forgot-them-at-the-shop-employee.

The signs are easily mounted and do not take up a lot of space. They weigh only about 20 lb; therefore, if you have an employee that is on weight-lifting restrictions, he or she can still easily put up the signs.

We had some special help in training our people on how and when to put up the traffic control signs. This job was made easy by the Iowa DOT. CFU has facilities large enough to host some traffic control seminars sponsored by the Iowa DOT. In recent months, we have been able to send almost all of our construction people and lineman to this six-hour course.

We also learned that the workers' traffic cones we were using were not correct. Therefore, we inspected all of our cones and, at the same time, cleaned them up and replaced the bad cones with 28-in reflectorized ones. Since then, the cone requirements have changed. We are now purchasing cones with two reflectorized stripes. As we replace our old ones, each CFU truck is equipped with ten cones. We do require that employees

set at least six cones per work site. We let them use their own judgment as to setting up additional cones and signs. The crew leader has only to radio a CFU supervisor to bring out more cones and signs, if it is necessary.

Sometimes you cannot predict what will happen and so you must take special precautions to protect the public and employees. Take the example of a major gas leak. It was a 4-in main that had a hole in it about the size of a quarter. The main was medium pressure and blowing at a good rate. We could not control traffic, repair the gas leak, and evacuate the nearby homes fast enough; therefore, we called the fire department and the police department for assistance. We are very fortunate to have a good relationship with these city departments. With additional support, you can protect the public, also it is cheaper than using your own employees. I am not saying that you should use these city departments all the time, but they do command special attention and are of great assistance when you need them.

A good working relationship with our fire and police and rescue departments is essential. We have received their permission to close down city streets when necessary. I realize that many of you do not have that option available, but it is something you could consider pursuing. We notify our dispatcher through radio communications on the street closing, and they contact the fire, police, and rescue departments immediately. Usually within a couple of hours, repair work is done, and the streets are back to normal. We found that this saves time and eliminates some of the hazards that go along with traffic control.

CFU makes an annual review of our work areas, and we have our employees critique their own work sites through photographs. It is fun to hear some of their comments. They compare the pictures from three years ago to the present. We did not use many traffic control signs, if you want to call them that. The cones that we had were 18-in high and so dirty you could not even tell they were orange. Our line trucks may have carried a couple of cones on them, but they were very seldom used. It was doubtful that they put their signs out all the time, but they did use their emergency flasher barricades and revolving yellow lights and set traffic cones on all jobs with the exception of changing street lights. CFU is presently checking into purchasing a portable directional arrow board for busy arterial streets. We have only eight such streets in Cedar Falls, and so we are presently studying this purchase with our general manager.

Cedar Falls Utilities is in the middle of a 10-year gas main replacement program. CFU will be contracting out the work again in 1991. When a contractor comes in for the construction drawings, he or she is also given a copy of the MUTCD Section VI and is advised to observe these regulations. Failure to comply will result in a work stoppage, and we had to take this action with our 1990 pipeline contractor. We realize that if a customer or a member of the general public is hurt, CFU will be held partially responsible.

CFU has moved away for the casual "no-cones" approach for traffic control in utility work zones. Instead, we have replaced this attitude with a more determined commitment from management and our employees. Impressive results are already being recorded. CFU had

no lost-time work accidents among its employees during 1990. The move from no-cones to no-accidents is paying big dividends.

CITY OF OVERLAND PARK, KANSAS
WORK ZONE TRAFFIC CONTROL PROCEDURES

Larry W. Settle
Senior Traffic Engineering Technician
City of Overland Park, Kansas

INTRODUCTION

Since the early 1980's, there has been a substantial increase in reconstruction and rehabilitation activities on the Nation's existing highway and urban street systems. The vast majority of this work has had to be accomplished while maintaining traffic through the use of work zones. Along with this accelerated rehabilitation activity there has also been a dramatic increase in accidents occurring in work zones, particularly in urban areas. According to the Federal Highway Administration, there were at least $15.3 billion in claims pending against State and other highway agencies in 1988. States made settlement payments to the tune of $150 million in 1987 alone. Even more alarming is the fact that, despite recent efforts to enhance safety in the work zone operations, the number of fatalities continues to rise annually--490 in 1982 and 782 in 1989.

The City of Overland Park has implemented a Work Zone Traffic Control Procedures Program that has produced significant improvements in the communication and project coordination between city staff and the agencies that work in our right-of-way. Prior to the institution of this program, agencies who performed work in the city seldom notified the Traffic Services Division before commencing work. This lack of communication, on many occasions, resulted in unsafe performance of work that was not compliant with city standards and, even more importantly, the Federal requirements contained in Part VI of the Manual on Uniform Traffic Control Devices (MUTCD). We support the belief that in order to be enforceable, safety regulations must be specific, and specificity gives people the exact information they need for correct application. This paper is an overview of Overland Park's initiation of improvement procedures and the resulting successes that have been achieved.

BACKGROUND

Prior to implementation of our enforcement program in late 1984, work zone traffic control in Overland Park was practically nonexistent. Most agencies performing construction and maintenance work in city streets were generally unconcerned about the safety and legal aspects of improper work zone traffic control. The few projects that did utilize some sort of traffic control plan (TCP) were poorly monitored, and adherence to the plan usually decreased as the project progressed.

The continued use of "typical" layouts, rather than project specific TCP's, was also a major problem requiring a great deal of time and effort on the part of city staff to come

up with a useable TCP that, in most cases, was needed "yesterday." After several unsuccessful attempts to correct these deficiencies through "voluntary" compliance, it became evident that the agencies committing these violations would continue to do so unless city laws were restructured to provide for enforceability of the regulations, and an aggressive enforcement program was initiated.

APPROACH AND DEVELOPMENT

Once definitions on requirements and penalties were clarified and approved by City Council for inclusion in the City's Municipal Code, a Traffic Control Handbook was developed to inform all utility companies, contractors, and consultants of these new regulations. Included in this Handbook are time-of-day work restrictions, permitting procedures, typical urban work zone layouts, sign spacing requirements, taper charts, and other related MUTCD and city regulations. The handbook was made available at no cost to all requesting agencies. Handbooks were also distributed to other city departments with the clear understanding that they were expected to "set the example" and abide by the same regulations that outside agencies were expected to comply with. (City employees received a day off without pay for noncompliance situations, and repeated intentional violation can result in termination.) Having consistency in the program for all agencies involved was crucial to the program's success.

RESULTS

As anticipated, the new program was not initially well received. During the first several months, the agencies that did comply did so reluctantly and usually as a result of continued warnings of permit revocation, assessment of a monetary fine, or personal contact with their insurance carriers. We also felt obligated to attend a number of relatively hostile "gripe sessions,"--disguised as "orientation and training" meetings--in order to help get the word out. Certain agencies were phoning in regularly to report "blatant violations" being committed by city crews and other agencies. (We even received an occasional photograph--courtesy of the local telephone utility.) However, once the initial start-up period ended and our requirements began to "sink in," we noticed a drastic improvement not only in contractor/city communication, but public relations as well. Traffic control complaints have continued to decrease steadily over the past three years, and the few violations that do occur are usually unintentional and resolved within the same working day.

Public officials from bordering cities have also remarked that our success seems to be "spilling over" into their cities as well, and they have requested copies of our ordinance and handbook for their own use and dissemination.

SUMMARY

As a direct result of this increased emphasis on work zone traffic safety in the City of Overland Park, we have experienced significant improvements in work zone traffic control operations during the past four or so years. This is reflected in improved traffic control plans, stricter compliance with city traffic control requirements, more use of unit pay items, and increased training opportunities for key project personnel. However, we also realize that we cannot reduce our efforts. An effective work zone enforcement strategy requires ongoing supervision, accountability, and documentation. To that end, the city is committed to providing continued training for new hires and refresher courses for experienced personnel in the area of work zone safety. City funds have also recently been allocated for the addition of a full-time traffic control inspector in early 1991.

Our next project of major significance is anticipated to be the revision of our Traffic Control Handbook and ordinance for compliance with the new standards contained in the ("still forthcoming") new and improved Part VI of the MUTCD--provided automobiles are still in use at the time.

LANE CLOSURE TECHNIQUES FOR TWO-LANE ROADS

Jon V. Jackels
Work Zone Safety Coordinator
Minnesota Department of Transportation

This paper discusses various lane closure techniques used on rural two-lane two-way roads in Minnesota. When discussing rural two-lane roads in Minnesota there is an extensive range of design and operation characteristics. These include traffic speed, design speed, surface type, general geometric design, traffic volumes, arterial, collector, highway system, etc. The challenge is to provide proper work zone traffic controls on all streets and highways whenever there is a work zone.

To facilitate exchange of ideas and concepts, it is necessary to examine Minnesota standards and guidelines used to establish work zone traffic controls. These contain common definitions of traffic controls terms. Review of the fundamental principles used to develop these standards and guidelines will also be beneficial.

The remainder of this paper includes identifying major problems observed in providing work zone controls on rural two-lane two-way roads, reviewing how these problems have been or are being resolved in Minnesota, and examining new technologies that are currently under investigation by the Minnesota Department of Transportation (Mn/DOT).

STANDARDS AND GUIDELINES

The work zone traffic control standards and guidelines used in Minnesota include the Minnesota Manual on Uniform Traffic Control Devices (herein referred to as the MMUTCD) which includes the Appendix B "Traffic Control for Short Term Street or Highway Work Zones" (herein referred to as the Appendix B). An additional guide is the Minnesota Traffic Engineering Manual--Chapter 8 "Work Zone Traffic Controls."

The MMUTCD is the basic standard applicable to all road authorities to provide all traffic control devices on their streets and highways. This manual has been appended to include the Appendix B. This appendix is a pocket-sized field manual and contains standards and guidelines for all short-term work zones on all streets and highways in Minnesota.

Chapter 8 of the Traffic Engineering Manual contains Mn/DOT's practices to provide traffic controls for long-term traffic control zones. Application of these practices is not mandated for other road authorities but is encouraged. It is stressed that all long-term work zones should have proper traffic management and traffic control plans included in the plans, specifications, and estimates.

DEFINITIONS

The following definitions are included in the Appendix B of the MMUTCD:

- **Short-term work**--any work on a street or highway where it is anticipated the activity will take one work shift (typically 6-12 hours or less) to complete.

- **Long-term work**--any work on a street or highway where it is anticipated the activity will take more than one work shift (typically 6-12 hours or more) to complete.

- **Traffic control zone**--the distance from where traffic is first affected by the activity and traffic controls to a point where traffic is no longer affected. Typically this is the distance between the first advance warning sign and the point beyond the work area where traffic is no longer affected.

- **Stationary traffic control zone**--any traffic control zone that remains in one place for longer than 15 minutes.

- **Mobile traffic control zone**--any traffic control zone that remains in one place for less than 15 minutes.

- **Moving traffic control zone**--any traffic control zone that is continuously moving.

- **Special traffic control zone**--any traffic control zone where the workers are performing tasks with little or no interference to traffic.

- **Decision sight distance**--the distance required by a driver to react properly to hazardous, unusual, or unexpected events where an evasive maneuver is more desirable than a hurried stop.

- **Good visibility location**--any location where the sight distance to the work area is sufficient to meet decision sight distance.

- **Low volume street or highway**--any street or highway where the average daily traffic (ADT) is less than 1500 vehicles.

FUNDAMENTAL PRINCIPLES

All of the standards and guidelines used to provide proper work zone traffic control are based on the application of fundamental principles of work zone traffic controls. Application of these principles must be emphasized for all work zones. These principles include:

- Keeping traffic safety an integral and high priority element of every project. This includes daily planning for short-term operations as well as traffic control plans for long-term operations. A key element of planning is to insure an ample supply of proper traffic control devices.

- Inhibiting traffic movement as little as practical.

- Insuring that motorists are guided by work zone traffic controls in a clear and positive manner. This is done by applying the concepts of positive guidance, using uniform traffic controls devices, and employing proper flagging techniques.

- Inspecting all controls routinely. This includes insuring that all devices meet the uniform standards, are in good repair, and are in the proper position.

- Training all personnel whose actions affect work zone traffic controls, appropriate to the job decisions required.

COMMON PROBLEMS

Mn/DOT's Work Zone Safety Review Team conducts multidisciplined reviews of work zone traffic controls as required by the Federal Highway Program Manual (FHPM). Members of this team are selected each year and conduct reviews of work zone traffic controls on all street and highway systems in Minnesota. This section contains common problems that have been observed by this review team.

Interviews with workers and field level supervisors revealed that for local low-volume two-lane rural roads, work zone traffic control standards are too restrictive and unreasonable. However, most personnel interviewed expressed the importance of proper traffic controls, the need for additional training, and interest in improved methods to provide proper work zone traffic controls.

The perception of unreasonable standards often results in improper or nonexistent work zone traffic controls. Examples observed include:

- Excessive distances from the advance warning signs to the work area.

- Lack of advance signing for all public streets and highways that enter the traffic control zone.

- Inadequate traffic controls for the operation in progress,.

- Lack of advance warning signs for short-term operations that occur within a construction work zone.

- Improper flagging procedures and equipment.

This perception also results in inadequate allocation of the resources (time, money, and people) needed to provide proper work zone controls. Often this results in lack of routine daily maintenance and surveillance of the work zone traffic control devices on long-term traffic control zones.

Many short-term maintenance operations move at 1 to 2 mi/h resulting in the work area getting too far away from the advance warning signs. This causes the work area to appear excessively long with little or no evident activity causing excessive traffic delays. This also results in cross traffic not being properly warned or controlled.

Many short-term maintenance operations take less time to perform than the time needed to install proper traffic controls, resulting in the attitude of many workers that it is more dangerous to install the traffic controls than to complete the work task with minimal or nonexistent controls. This results in workers carrying out tasks outside the work area and workers not wearing high visibility clothing.

For operations on two-lane roads where traffic is carried through the work zone, it often becomes necessary to control two-way traffic on a single lane. Improper control techniques confuse drivers and result in conflicting traffic movements that may cause accidents. The most common problem observed is improper flagging techniques, including poor positioning, improper signals. and inattentiveness to traffic.

SHORT-TERM WORK ZONE TRAFFIC CONTROLS

Generally long-term traffic controls on two-lane two-way roads involve complete closures and detours. Therefore, most of the problems observed on two-lane two-way roads involve short-term work zone traffic controls. The remainder of this discussion will concentrate on these short-term traffic controls.

The first effort in providing uniform work zone traffic controls for short-term work was the development of the Appendix B to the MMUTCD. This pocket-sized work zone traffic control guide was first developed in 1972 to aid field personnel in selecting and installing traffic controls for short-term work zones. This assistance is accomplished by showing applications of basic principles to be observed by all agencies that perform short-term work on any street or highway. Development of this standard included a comprehensive training program intended for all individuals involved with the planning, designing, installing, maintaining, and inspecting of short-term work zone traffic controls.

The typical work zone traffic control applications included in the Appendix B are divided into low-speed and high-speed streets or highways. Because most rural roadways are high-speed, the discussion will be limited to these applications. For high-speed two-lane two-way roadways the Appendix B contains guidelines for the following:

- Low-volume roads, including guidance for application of single- or two-flagger operations.
- Mobile traffic control zones.
- Alternating position for stationary operations that cover a relatively long segment of highway in a short period of time.
- Application of decision sight distance concepts to determine good visibility locations for mobile and moving operations.
- Special operations.
- Worker and flagger visibility.

Low-Volume Roads

The definition for low-volume roads contained in the Appendix B includes any road with an ADT of 1500 or less. This definition is based on experience and is often modified by local road authorities.

The typical traffic control layout for control of two-way traffic on a one-lane road is shown in Figure 1. It shows two flaggers, each controlling traffic at opposite ends of the work area.

The typical traffic control layout for single flagger applications on low-volume roads is shown in Figure 2. Use of this strategy is limited to short-work areas where the flagger has good sight distance in both directions. In these situations the flagger controls vehicles in the closed lane allowing the opposing traffic to flow freely. When the way is clear, the flagger allows the controlled traffic to proceed past the work area. It is important to instruct each driver to return to the right lane immediately after the work area.

Mobile Traffic Control Zones

For traffic control zones that remain in one place for less than 15 minutes, mobile traffic control schemes have been developed. The use of a 15-minute period was based on field experience. The typical traffic control layouts for mobile operations are shown in Figures 3 and 4. Generally the signs are truck mounted so they move with the operation.

The problem with this concept is deciding when to use stationary or mobile traffic controls. It is tempting to call all work zones mobile and provide minimal controls in all situations. However, the intent of the mobile layouts is to provide proper traffic controls for operations that cover relatively long segments in relatively short periods of time.

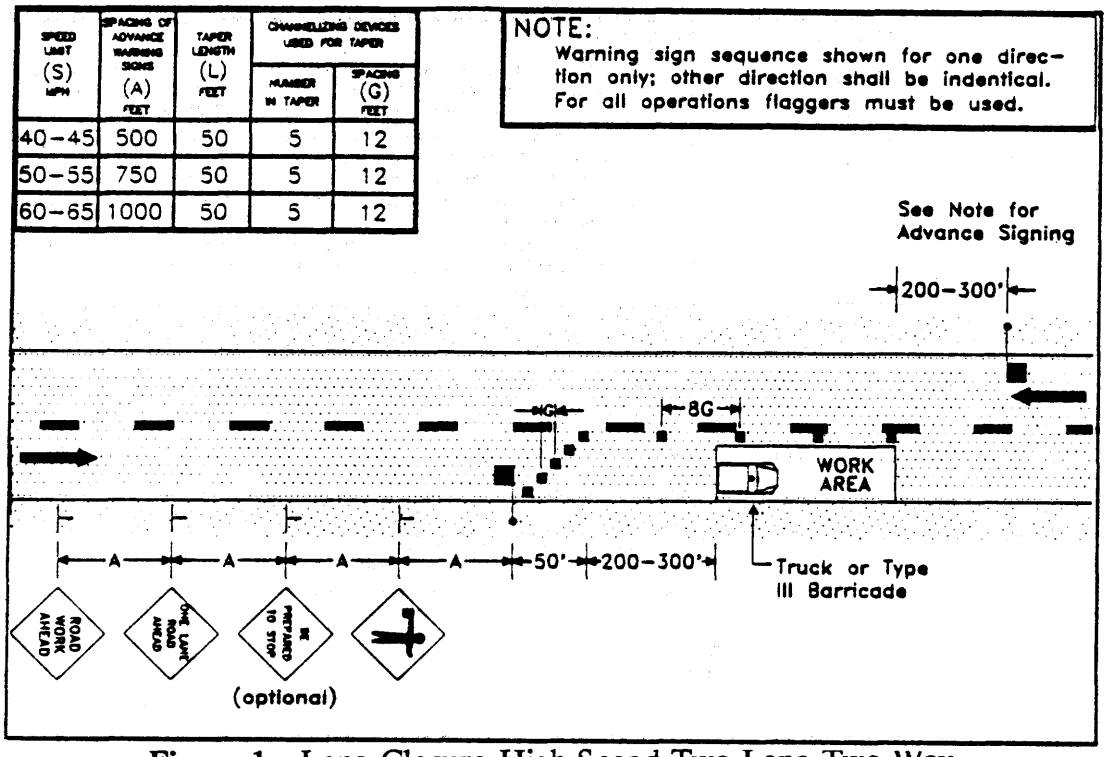


Figure 1 - Lane Closure High-Speed Two-Lane Two-Way Low-Volume Street or Highway

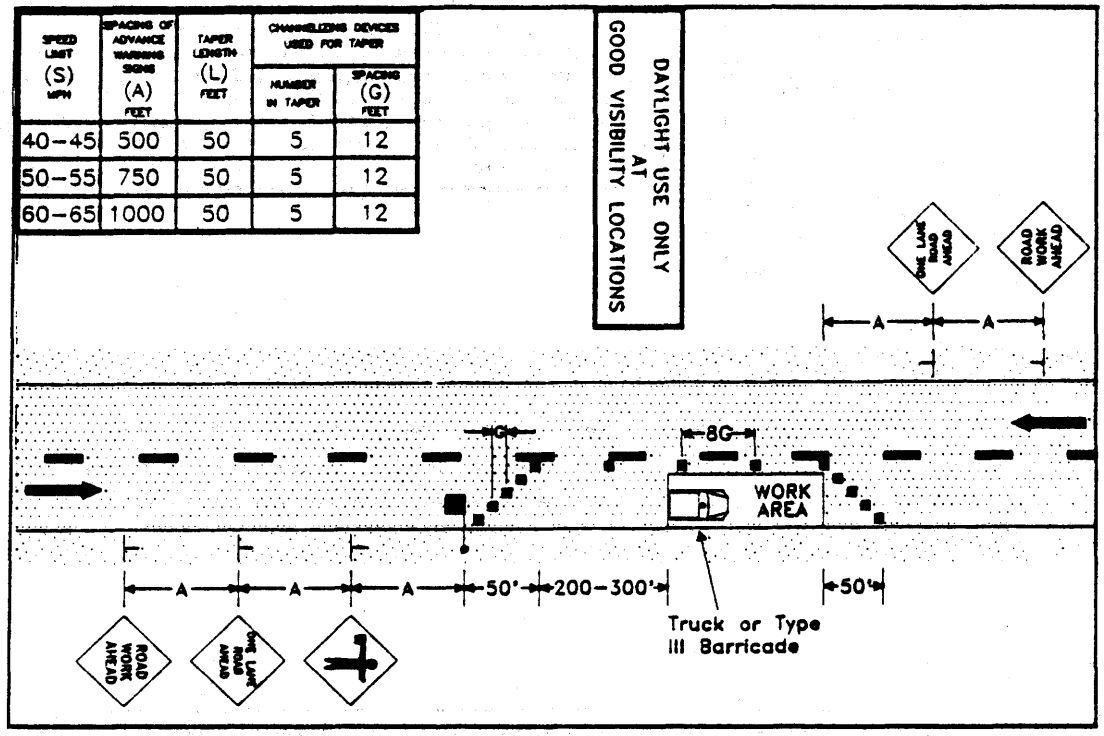


Figure 2 - Lane Closure High-Speed Two-Lane Two-Way Street or Highway

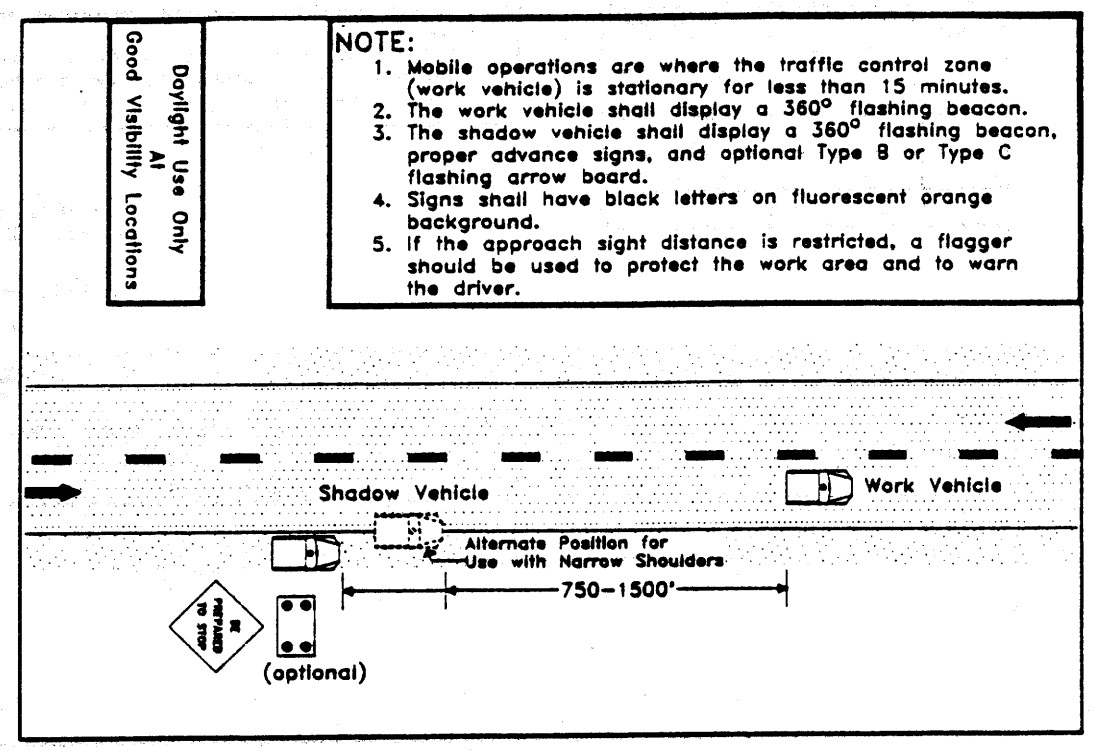


Figure 3 - Lane Closure for Mobile Traffic Control Zones
High-Speed Two-Lane Two-Way Street or Highway

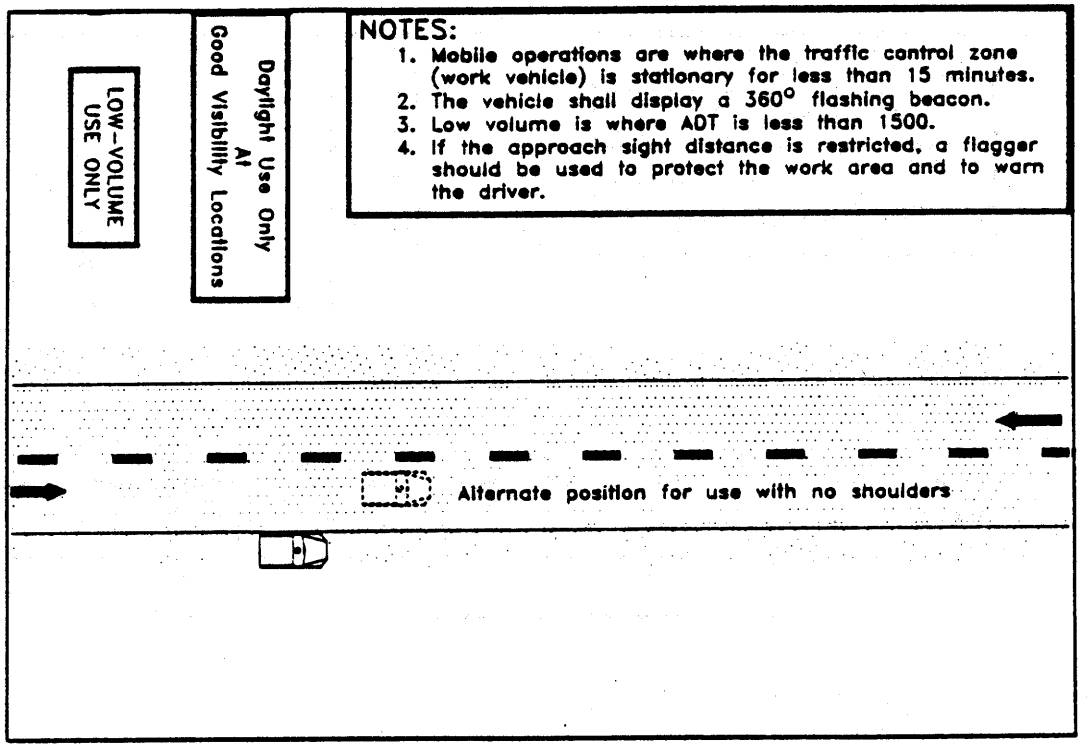


Figure 4 - Lane Closure for Mobile Traffic Control Zones
High-Speed Two-Lane Two-Way Low-Volume Street or Highway

To explain the proper applications, the definition of mobile traffic control zone must be examined in detail. A mobile traffic control zone is any traffic control zone that remains in one place for less than 15 minutes. A traffic control zone is the distance from where traffic is first affected by the activity and traffic controls to a point where traffic is no longer affected. Typically this is the distance between the first advance warning sign and the point beyond the work area where traffic is no longer affected. Therefore, to be considered a mobile zone the entire traffic control zone, not just the work area, must move. Work areas that move every 15 minutes within the same traffic control zone are considered stationary traffic control zones.

Alternating Position for Stationary Operations

For those operations that are defined as stationary traffic control zones, yet cover relatively long sections of roadway in a short period of time, the alternating position scheme has been developed. The typical traffic control layout for this situation is detailed in Figure 5.

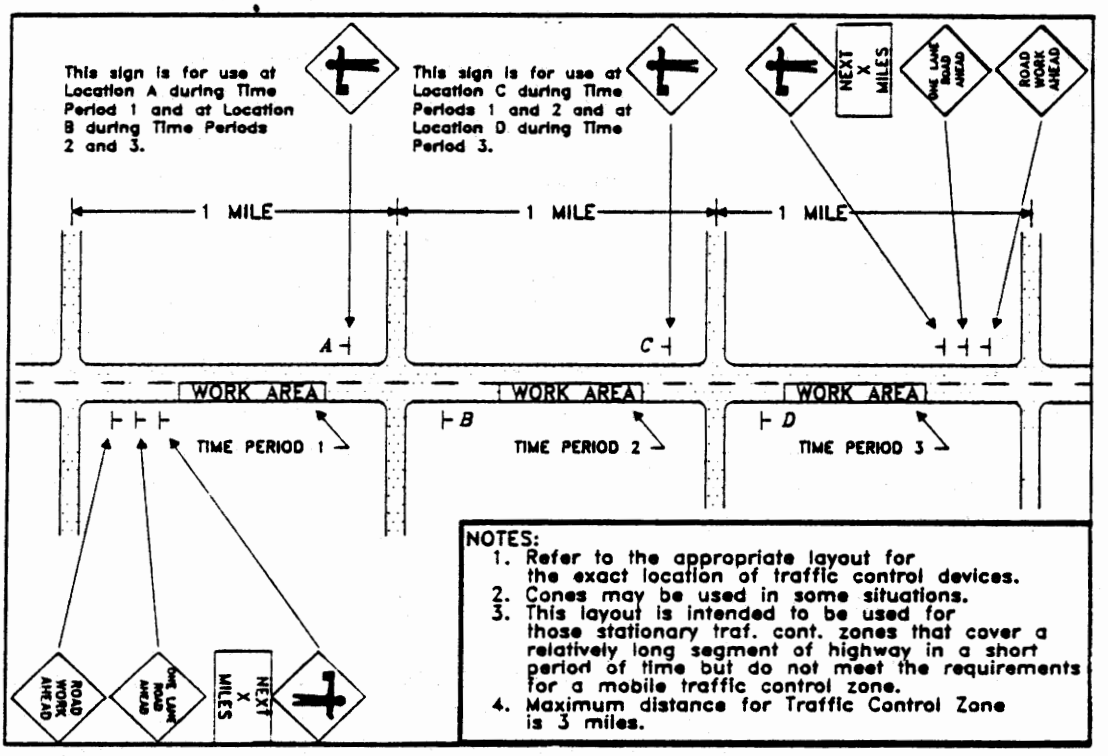


Figure 5 - Alternating Position Stationary Traffic Control Zone
High-Speed Two-Lane Two-Way Street or Highway

For the alternating position the advance warning signs are installed up to 3 mi apart and intermediate FLAGGER AHEAD signs are used to remind drivers that a flagger is ahead. These FLAGGER AHEAD signs are moved to the other side of the roadway as

the flagger passes this position. This results in the flagger never being more than 1 mi from the last FLAGGER AHEAD sign.

Application of Decision Sight Distance Concepts

The typical layouts and general principles contained in the Appendix B are based on decision sight distance, as detailed in the American Association of State Highway and Transportation Officials (AASHTO) Geometric Design of Highways and Streets - 1984 ed. This concept has been abbreviated and incorporated into the Appendix B to aid in defining good visibility locations. Table 1 shows the basic distances that are used in the Appendix B. These distances provide "rule of thumb" distances for field personnel when deciding if proper distances exist for specific situations. Generally these distances are used for single flagger operations on low-volume roads and during mobile operations because the normal advance signing is nonexistent. These distances are also used to determine the vehicle spacing for mobile and moving operations.

Table 1 - Suggested Decision Sight Distance

Posted Speed Limit (mph)	Suggested Decision Sight Distance (feet)
0-35	750
40-45	950
50-55	1200
60-65	1400

Special Operations

Special traffic control zones are any traffic control zones where the workers are performing tasks with little or no interference to traffic. Generally the presence of the vehicle and worker should not "surprise" the driver or cause any erratic maneuvers. The typical traffic control layout for this situation is detailed in Figure 6. Again, extreme care must be taken to apply the guidelines of decision sight distance and avoid improper applications.

Worker and Flagger Visibility

The MMUTCD requires flaggers to wear approved orange clothing, such as a vest, shirt, or jacket. The Appendix B extends this requirement to all workers not separated from traffic by a positive barrier. For nighttime use this outside garment must be retroreflective. The exact configuration of the retroreflective material is not specified. However, the Appendix B requires the design configuration to be visible through the full range of body motions.

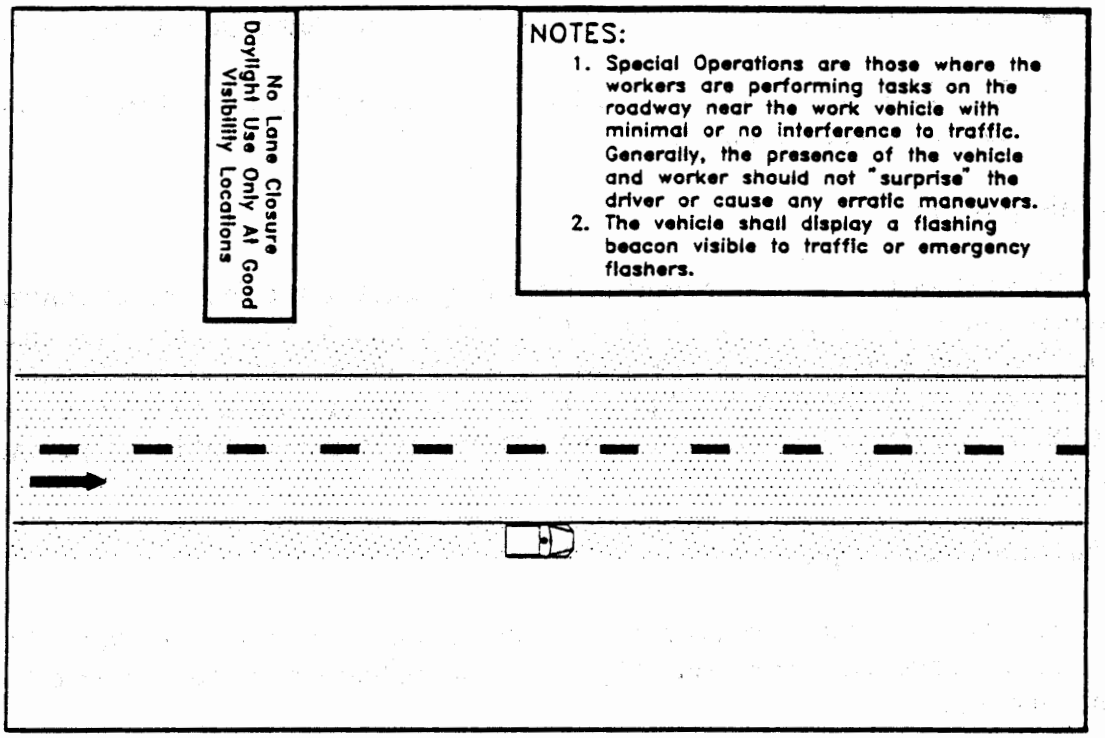


Figure 6 - Special Traffic Control Zone with Work Vehicle Off the Traveled Roadway High-Speed Street or Highway

Additional Standards and Guidelines

Although the present standards and guidelines include direction on selecting different traffic controls for different situations, additional criteria are needed. To insure that traffic control standards and guidelines reflect the different roadway characteristics, further development of tier standards and guidelines allowing the selection of work zone traffic controls based on traffic characteristics is proceeding.

NEW TECHNOLOGIES

Due to the high exposure and risk, application of new technologies in providing work zone traffic controls is normally restricted to high-volume multilane roadways. Mn\DOT is actively pursuing application of new technologies to improve work zone traffic controls on two-lane two-way roads. These applications include the following:

- Reflectorized roll-up signs for short-term work zones.
- Use of portable traffic signals to control two-way traffic on a one-lane road or bridge during short-term operations.

- Evaluation of portable rumble strips for short-term work zones.
- Evaluation of a "STOP/SLOW" paddle with supplementary flashing lights.
- Development of robotics to control vehicles, equipment, and traffic control devices to reduce crew exposure.

Roll-up Signs

The use of fluorescent retroreflective roll-up signs to provide proper controls for short-term work has been a standard in Minnesota since 1987. These signs are extremely visible, easily moved, and readily accepted by highway workers. Although used for all short-term work, the primary improvement has been for short duration operations, similar to surveying, where there is minimal impact on traffic and very little equipment visible to the traveling public.

Portable Traffic Signals

The use of portable signals may have the capability to improve worker safety and increase productivity. However, they will never completely replace the need for flaggers in work zones.

The use of portable traffic signals to control two-way traffic on one-lane roads during short-term work is currently being evaluated by Mn/DOT. All of the applications on high-speed roadways have been successful. Therefore, standards and guidelines for the application of portable signals are currently being developed. These standards include details of the application of portable signals not contained in the Federal MUTCD. These details include type of work, traffic volume, length of work area, sight distance, traffic speed, warrants for the application of portable signals, requirements for signal displays, suggested timing strategies, and typical traffic control layouts.

The warrants for the application of portable signals must contain recommendations on when and where to use signals as opposed to flagger control. These recommendations should include duration of operation and frequency of surveillance.

A major consideration is for signal display requirements. This includes the location and number of signal faces. Standards currently being developed require two faces in each direction. The primary location is to the right of the traveled lane with the second face being over the lane or to the left of the roadway.

Advanced signing and other traffic controls used in conjunction with portable signals should be similar to those in Figure 1 with the addition of portable stop bars and replacing the FLAGGER AHEAD sign with a SIGNAL AHEAD sign. These typical layouts should include suggested timing strategies to aid field personnel in application of these signals.

Portable Rumble Strips

The use of rumble strips to alert drivers to potential hazards is common practice in Minnesota. Generally these hazards are unexpected signalized or stop sign controlled intersections. Mn/DOT has begun evaluation of a portable rumble strip that may be used in advance of flagger or portable signal control of two-way traffic on a one-lane road. Although testing is incomplete, this device has performed favorably in controlled impact and skid tests and actual open highway use. The major remaining concern is the erratic behavior of traffic when encountering this unfamiliar device on the roadway. This portion of the evaluation is not complete and will continue in 1991.

The current efforts of the Strategic Highway Research Program (SHRP) project H-109 contain the development and testing of a portable rumble mat. Mn/DOT hopes to work with the contractor on this portion of the project.

Flashing STOP/SLOW Paddle

Flaggers have often commented that drivers ignore their commands and run the stop signs they are using. When questioned these drivers state they did not see the flagger even when all advance signing is used. A flagging paddle with supplementary flashers has been developed and is being evaluated by Mn/DOT.

Again the current SHRP project H-109 contains the development and testing of a STOP/SLOW flaggers paddle with strobes. Mn/DOT hopes to work with the contractor on this portion of the project.

Robotic Control

The use of remote control vehicles to provide personnel protection and traffic controls is another suggestion contained in SHRP Project H-109. Mn/DOT has offered a 1991 single-axle dump truck to SHRP for use in development of this technology. This vehicle will be equipped with a truck-mounted attenuator (TMA) when used to provide protection for the workers. This vehicle will also be used to mount signs for mobile and moving operations, as well as for speed control.

CONCLUSION

Any discussion on the techniques of providing traffic controls on rural two-lane two-way roads must include: the basic standards and guidelines; advance planning, including training; regular inspection and maintenance of traffic control devices; and proper applications of the basic principles of work zone traffic controls. This total concept approach must be used if any work zone traffic safety efforts are to be successful.

The key to making proper work zone traffic controls and safety work is to insure that all traffic control standards and guidelines contain the proper options to allow the traffic controls to be adjusted to adapt to specific applications. This results in proper traffic controls that are reasonable for workers and the traveling public.

APPLYING THE MUTCD TO RURAL ROADS

Larry C. Smith, P.E.
Chief, Engineering and Operations Division
Federal Lands Highway Office
Federal Highway Administration

Before I talk about applying the Manual on Uniform Traffic Control Devices (MUTCD) to rural roads, I will give you a little background as to how the Federal Lands Highway Program fits into the Federal Highway Administration. As many of you may know, approximately one-third of this country is owned by the Federal government and includes some 360,000 miles (580,000 km) of Federal-owned roads. These roads provide access to and through Federal Lands for the management and public use of these Federal resources. The Federal Lands Highway Office administers a program of highway and bridge design and construction to build or reconstruct many of these roads. Once completed, all of our projects are turned over to the owning jurisdiction for maintenance. So one of our challenges is adopting the MUTCD and other national standards to the diverse range of standards and needs of the agencies we work with so that what we construct will be accepted and maintained. Therefore, particularly in the area of traffic control through work zones, we try to use the MUTCD to its fullest to meet or exceed local needs and standards, rather than create a conflict with those standards.

It is the application of Part VI of the MUTCD dealing with work zone traffic control on these kinds of roads that is today's subject. For the purpose of my discussion today, I will talk about two-lane rural roads where terrain, right-of-way, environmental, aesthetic, and budgetary constraints generally limit geometric and sight distance application to the minimum. These conditions also generally limit application of desired traffic management practices during construction. That is, alternate routes are seldom available, nor are road closures or constructed detours acceptable. Consequently, we are invariably funneling the traffic through the construction and accommodating it with signs, flaggers, pilot cars, delineation, and lots of patience.

Another issue to consider in making the MUTCD work on these types of roads is that many projects are in remote areas and because of the size and light traffic do not warrant experienced traffic control subcontractors. The contractor will either assign the traffic management duties to his superintendent or a foreman, both of whom will likely place permanent construction responsibility above traffic management. Furthermore, the contract administration staff is not likely to be as experienced as those assigned to the larger urban or freeway projects. These conditions require two commitments from the agency and the contractor to properly apply the MUTCD. First is an intensive training effort of both agency and contractor staff and second is a need for detailed traffic control plans in the contract. The latter provides for a clear understanding of what is expected in the way of traffic management by the project staff and the contractor. Therefore, it is important always to use the expertise of the design process to lay out a workable traffic

control plan in the contract. The former gives the staff reasonable knowledge to recognize when changes are needed and when to consult with other experts. Combined these will provide positive and consistent application of the MUTCD to meet traffic needs during construction.

There are, however, a number of assumptions on which the MUTCD is based, which need to be considered when applying it, particularly to rural roads. As an example, we assume that the standards in the MUTCD are minimum standards which apply to both rural and urban roads regardless of volume, speed, or other conditions. Unfortunately, some of the minimum standards are difficult to apply to rural roads and consequently the manual is inappropriately applied. This often leaves the motorist without consistent guidance just because we think the minimum requirements discussed in the manual are not applicable to our situation. This is not to say that the MUTCD does not provide the latitude to accommodate a wide variety of situations; but, it does not always provide the latitude to reasonably address rural, low volume road conditions. I will discuss this more, later.

Another implication, particularly with respect to the example traffic control layouts found in the MUTCD, is that construction zone traffic should be accommodated at a speed which is nearly the same as the prevailing highway speed. If that is not reasonable--and it often is not on our roads--then the traffic layout may have to be supplemented with additional advance warning and regulatory signs to transition speeds to the level that can be safely accommodated. This leads to a third problem, which assumes there is effective legislative, regulatory, enforcement, and media support to implement and communicate effectively the traffic management plan to the public. If you have to petition the State Highway Commission for permission to put up a regulatory construction speed-limit sign, or if you have to get special approval for police enforcement in your construction zone, the "deck is stacked" against you before you start. Media support is mentioned here because it is often important to get out essential information on closures, delays, etc., as well as for general public relations. This is important even on low-volume roads and particular recreation roads where unfamiliar motorists may drive great distances only to find access limited. Federal Lands currently has a project in Arizona where we considered public awareness and media coordination so important that we hired a public relations firm to perform that function. Information is communicated to the public through several media including radio, television, and the placement of posters and brochures in local establishments used by tourists. We feel this makes the traffic control work and builds public confidence in our traffic management. In this instance, the results have been remarkably good.

Those are just a couple of points I wanted to make before getting into some specific applications of the MUTCD and the latitude provided. The MUTCD, either specifically or by simply omitting specific standards, gives the user substantial latitude in certain areas to accommodate particular rural and low-volume situations. The following are the points I would like to make today:

- Sign Sizes--Sections 6B-1 and 6B-13 of MUTCD permit smaller than standard signs in certain circumstances. Generally any smaller than standard sign is applicable only if low prevailing speeds assure time to respond to the sign message. Smaller than standard regulatory signs must be legally authorized. However, as noted for speed limits, legal authorization can consume considerable resources and generally is not done. The alternatives are to 1). install a smaller sign, which may or may not be appropriate for conditions, or 2). use the standard size but because of physical roadside limitations place it in an ineffective or partially invisible location. Either of these decisions increase the agency's risk should an accident occur. This problem is particularly true of construction-approach warning signs for which the standard is 48 in (122 cm) with a minimum 6-foot (1.8 m) offset. Yet, the shoulder widths and clear width to the trees on the roadside may be less than 10 ft (0.9 m). If this is the case, the use of a smaller sign, with flags or lights to attract motorists' attention that is fully visible will provide a more positive message to the motorist. That is really what we want to do. In addition, it is absolutely essential that good judgement be used when placing signs to make sure they are as visible as possible given the roadside conditions on the project.

- Sign Sequences--Sections 6B-14 and 6B-22 of MUTCD permit modification to standard sequences of warning signs. Depending on conditions, these modifications may mean additional signs or fewer signs. The most important issue is the message we portray, or fail to portray, to the public. The major problems are: 1). over signing, 2). under signing and, 3). inappropriate signing. What is over signing? Generally speaking, only one sequence of messages should be used at a time. However, particularly at the beginning of projects, you will see the "standard" sequence of advance warning signs and a supplemental intermixed set of lane-closure or flagger-ahead signs for "today's" operation. This is confusing, and to make it work, only the important message should be posted and other messages should be avoided. This can be done by removing or covering duplicate signs or spreading the traffic control out so that one maneuver is completed before a second is required. What is under signing? In long, drawn-out construction zones there is a tendency to believe that the one sequence of advance warning signs is good for all operations within the construction zone with the possible exception of lane closures. This certainly isn't true. Emphasis should be placed on using a sequence that includes the W21-1a "WORKER" or W21-3 "MACHINERY" sign at any specific site where work is underway within the construction zone, even if the work does not continually encroach on the travel way. This will remind motorist to be alert for construction activities and traffic or workers entering the roadway. Finally, what is inappropriate signing? It is appropriate and necessary to put up special supplemental signing to designate such things as lane closures and flagging operations within work zones. But, when we quit work and leave these signs up, the driving public loses confidence in the overall traffic management. Unfortunately, this is one of the most common faults and the one that poses a safety problem to the motorist and workers on the

immediate job. And, in addition, it poses safety problems on all other jobs as well. That is, when we, as traffic managers destroy the traffic control credibility, we lose the public confidence. Somehow I think our use of inappropriate signing gave rise to public complacency in our construction zones and lead to additional signs like "GIVE EM A BRAKE," which doesn't really contribute to the information the motorist needs while trying to traverse a work zone. This should not be taken in the wrong way. The "GIVE EM A BRAKE" educational program is excellent. But the sign does not belong in the construction sequence to add information and maybe confusion where the motorist really needs clear and concise direction. Signing is generally simple, if we stop and think for a moment, look at what we have installed--or haven't installed--and consider the work going on, we will know what is important and what needs to be said. That is all that the public wants and expects.

- Short-Term Pavement Marking--Section 6D-3 discusses the use of temporary or short-term pavement markings. It has undergone considerable change over the past couple of years and is just beginning to be implemented in its final form. In general, pavement markings provide the motorist with two pieces of information: lane positioning and passing safety. The MUTCD emphasizes the latter by indicating that lane positioning is a supplemental benefit and recommends full striping, or short-term striping, be used at all times. Although full striping is desirable, on rural projects, and particularly projects with low traffic volumes, it is often not practical to apply a full compliment of striping each day. This is particularly true of no-passing zone striping. The MUTCD does recognize low-volume rural road needs and permits agencies to develop special standards for low-volume roads which allow short-term markings to be used in excess of two weeks. We in Federal Lands Highways are in the process of developing a policy for low-volume roads which will allow short-term markings to be used up to six weeks. For the purposes of this policy, we have defined low volume as 1000 vehicles per day or less. The six-week time frame is the time from initial obliteration of the existing striping to completion of final stripping. This time period includes all intermediate stages of work and does not restart with each successive lift of pavement or movement of traffic pattern. If the proposed construction time is longer, then temporary or permanent striping, as appropriate, is required for the project. While this time frame might appear arbitrary, it was selected to allow a reasonable amount of pavement to be completed and permanent striping placed without disrupting the contractor's operations. In addition, we hope that it will allow for the installation of most permanent striping without the need for temporary striping on the final lift of pavement. This is because we require temporary striping on the final lift of pavement to be removed prior to placement of permanent striping. Of course, full or short-term striping should be provided whenever possible. It is absolutely essential during long suspensions, such as winter shutdown or during long-term stage construction activities no matter how light the traffic is.

- Signs in Lieu of Pavement Markings--On low-volume roads, Section 6D-3 also allows for the use of signs in lieu of pavement markings to designate no-passing zones for periods longer than three calendar days. On many projects the paving operations move along at a pace that does not justify daily striping. In these cases we also allow signing in lieu of pavement markings to be used for up to six weeks. However, we plan to require the use of temporary raised pavement markers to provide guidance to the motorist. These markers will be placed on 40-ft (12.2 m) or 80-ft (24.4 m) centers to provide additional guidance in the construction zone that is otherwise typically dark and without significant roadside delineation. Temporary raised pavement markers are very useful on surface treatments and seal coats where paint is not practical until the surface has been cleaned of lose material and the asphalt completely cured. Temporary raised pavement markers are available with pull off shields so that they may be installed prior to the surface treatment and then uncovered to expose the reflective surface. The use of these markers alone is a questionable interpretation of the MUTCD. We feel the use of temporary raised pavement markers on interim lifts of pavement and surface treatments will offer the motorist guidance without indicating permissive passing as 2-ft (0.6 m) and 4-ft (1.2 m) stripes might in no-passing zones.

- Temporary Raised Pavement Markers--Temporary raised pavement markers can also be used to supplement temporary striping or can be used in lieu of all temporary striping. The latter application is particularly useful on the final lift of pavement where it is impractical to place and remove striping. When used in lieu of all short- term striping, these markers are required to be on 5-ft (1.5 m) centers to delineate solid lines and 3 equally spaced markers for 4-ft (1.2 m) broken lines and 2 markers for 2-ft (0.6 m) broken lines. These markers are also very effective when used to supplement paint or tape striping because they are much easier to see than striping alone, particularly in inclement weather. Temporary raised pavement markers are relatively inexpensive, are easy to install, and easy to remove when permanent striping is installed.

- Self-Regulating One-Way Operations--Occasionally for a box culvert installation or a bridge deck replacement we need to maintain two-way traffic on one lane, 24 hours a day. While one-way traffic can, and usually should, be maintained by flaggers during working hours, it is not always possible to reopen both lanes during nonwork hours. For these situations, Section 6F-6 provides for self-regulating traffic control, if it can function safely at the volumes anticipated. Self-regulating traffic control is accomplished with either "STOP or YIELD" signs when the work site length is short and visibility is good. The use of "STOP or YIELD" signs is preferable because the interruption of traffic flow is based volume and demand rather than a fixed time and consequently is usually less. When visibility is not good, a temporary traffic signal system complying with Section 4E-24 to 4E-28 is a very effective means of regulating two-way traffic on one lane, 24 hours per day. Temporary traffic signals work well as the main traffic management tool, even during work hours, where a positive barrier is used between the work and traffic,

such as for bridge repair: The main requirement is that the signal heads and stop area are clearly visible to approaching motorists. When a positive barrier is not provided and workers and equipment are entering the single travel lane at random locations, the recommended approach is to use the signals only during nonwork periods. Flaggers and, when appropriate, pilot cars should be used during work hours to provide more positive guidance to the motorist and safer work conditions for the workers. Either of these options is generally cheaper than 24-hour flagging, but maintenance, security and vandalism are a greater problem when 24-hour self-regulating traffic control is used. Provisions must be made in the contract for inspection on a regular basis to avoid a hazardous situation.

- Roadside (Long Term) Delineation Standards--Part VI of MUTCD provides standards for the delineation of a closed travel lane and a closed shoulder. However, there is no standard for delineating previously obliterated shoulders or the edge of travel way where the pavement has been removed or obliterated. These situations usually create drop-offs and are potentially hazardous. They may go on for several thousand feet or even miles. It is left to the contracting agency to determine the types and spacing of traffic control devices to provide adequate delineation based on the volume, geometric, and anticipated duration of use at the site. Our first priority is to minimize drop-offs by requiring that shoulders be graded up to the pavement edge at the end of each work shift, if at all possible. In addition, we minimize the potential hazard by placing cones or other channelizing devices at intervals of 50 ft (15.2 m) to 300 ft (91.4 m), depending on geometric conditions and severity of the hazard. The spacing is left largely to the judgement of the project engineer because he is most familiar with on-site conditions. As with sign messages, day and night reviews of ongoing operations and the traffic control provided, with emphasis on hazard delineation will offer even the inexperienced sufficient insight to meet the motorist needs.

  Furthermore, with the significant advancement in delineation materials and devices and the inexpensive cost of items, there is little excuse anymore for not making all hazards within the work zone visible both day and night. Even with good retroreflective material to start with, it is important to keep it that way. That is, maintenance of both placement and cleanliness must be a project priority. To make this happen we have a standard specification that requires the retroreflection on signs, barricades, and other traffic control devices be maintained at a minimum of 75 percent of the minimum specified SIA value for Type II sheeting and 50 percent for Type IIA or TYPE III.

- Positive Separation (Concrete Barriers)--Section 6C-10 gives general guidance on the use of temporary concrete barriers. However, specific application standards are left to the contracting agency. Concrete barriers are used less on rural construction projects as compared to their use on urban projects. Generally, this is due to cost and the presumed lower risk with lower traffic volumes. However, when severe hazard situations exist, these barriers should be used even on the

lowest volume roads. I think that in the coming years, liability and other considerations will significantly increase the use of concrete barriers on rural, low-volume projects, in spite of costs. We are encouraging our staff to take the lead and use these barriers more, particularly adjacent to open excavation and severe edge drop-offs that are exposed for more than a few days at a time.

All of these examples of latitude an agency may exercise are tied basically to speed and/or volume rather than to the rural versus urban character of a road. As a general rule, as the speed or volume increases, the agency's latitude or discretion with respect to application of the standards decreases. The important issue should always be to look at what the motorist needs for guidance and the worker needs for safety, and the appropriate use of the manual will usually follow.

In summary, the MUTCD is a valuable document that is usable and useful for a wide range of types, volumes, and standards of highways and streets, including low-volume, rural roads. The MUTCD comes closer than most other similar resource guides in our profession, to being a recognized and respected standard across the country. But it needs to cover better the special needs of low-volume rural roads. To make the MUTCD work, it is up to us as the traffic control experts (owners, contractors, and suppliers alike), particularly in construction zones, to give clear concise, and, most of all, consistent guidance to the motoring public so that educational efforts are successful and the public trust is retained. This is the only way we will improve safety for the motorist and worker alike.

TRAFFIC CONTROL FOR LOW-VOLUME ROADS

Robert L. Morrison, P.E.,P.S.
County Engineer
Hancock County, Ohio

Nationally there is no specific number of vehicles per day to define a low-volume road. In the absence of a formal definition, perhaps it would be helpful to you to know the size of the jurisdiction I serve. This may give you some insight into what I consider to be low-volume roads. Hancock County is 24 miles square, seated in the heart of the agricultural belt in northwestern Ohio. Our terrain is basically flat with a county population of approximately 67,750. There are 427 miles of hard surfaced county highway under the direct jurisdiction of the county engineer. There are 536 miles of hard surfaced township roads under the jurisdiction of the Township Trustees.

There are 17 townships. No functions can be performed on the township road system without review and approval of all contracts by the county engineer. There are 455 bridges in the county, 10 ft in span or greater, under the direct jurisdiction of the county engineer. This includes all structures on township and county roads and in all municipal corporations within the county with the exception of State highways traversing through the county.

Structures on State highways within municipal boundaries are the responsibility of the county engineer to maintain. This, in essence, makes approximately 1,000 miles of county and township roads under the jurisdiction of the county engineer. Only about three miles of the whole system would be considered gravel or mud. No one lives on these roads which are used for agricultural purposes with little or no maintenance. Approximately 80 percent of the 1,000 miles of highway are in the 30- to 40-ft wide right-of-way category. The rest of the right-of-ways would fall in the 40- to 60-ft range, none being wider than 60 ft.

Farming is basically grain, and all the original right-of-way fences have been removed so there is no definite right-of-way marker that existed years ago when farms were fenced. In addition, along many miles of this highway there are deep agricultural ditches on one side of the pavement which drains the adjacent land. These occupy either part or all of that right-of-way available on one side. It has been said by many that we probably grow our best agricultural products on the highway right-of-way. By statute we have easements for highway purposes, as opposed to ownership.

For the most part, our department's daily routine operations would fall in the moving work zone categories. The type of work would be patching, shoulder repair, mowing, and generally light maintenance. Traffic volumes in these zones will range anywhere from 10 to 100 vehicles per day. In low-volume situations, traffic control is done primarily with flashers mounted on the vehicles with workers personally guiding the one or two vehicles

that may pass around the zone during the operation. Generally, traffic speeds would be considerably less than 50 mi/h. All operations of this nature are conducted in daylight hours. Visibility is usually very good. Foggy and rainy hours we stay off of the pavement. Being in flat terrain we do not have the hill/curve situations to deal with.

When the work zone is in areas where traffic volumes are larger than 100 vehicles per day, advance signing is placed at either end of the project area warning of specific activity occurring in the area. If passing lanes are necessary, workers with sign paddles are used to conduct the traffic around the work zone. We are very pleased that flags have been removed from the manual for this purpose and paddles used in their place. It has been our experience that flaggers do not send a clear message to the motorists, especially on windy days. The sign paddle is very definitive and generally its use is not abused. Colored vests and appropriate wearing apparel is utilized in those areas where traffic volumes are such that visibility is important. I might state that many of our highways in the rural area are a lane or a lane-and-half wide. Most of the pavements are in the 14 to 16 ft category and, as such, that in itself controls a lot of the speed. In my 30 years tenure in the county highway department, I cannot find a record of any accident or injury or personal property damage occurring within the work zone or as a result of the work zone in moving operations.

Operations, such as seal coating an existing stretch of highway and/or one or more day's closing of a highway, require a more detailed treatment for traffic control. In operations that only transpire in one day during working hours we do not use any warning lighting. Basically the black and white "Road Closed" sign or "Road Closed to Through Traffic" signs are utilized. These are generally placed in the center of the pavement at each end of the project at intersecting roads. Placement of this device can be a problem at times on narrow pavements because you wish to discourage the use of this zone by the public and yet you want to permit the use of the same zone for the passage of construction vehicles. We use a stop sign on the back of this "Road Closed Sign"; however, this has been questioned by some of our law enforcement agencies. We do not use yield signs in the county. Over the years we have converted from using engineering grade sheeting to high intensity reflective grade sheeting for work zone signs. We have our own sign producing facility, and it is relatively easy for us to produce a sign on short notice.

Where the large black and white "Road Closed" sign is used, we do not use a guard person. These signs are mounted on telspar telescoping posts, set on the pavement, sometimes temporarily secured with a railroad spike, but generally held down with a sand bag. This makes the installation forgiving should a vehicle strike the sign or its supports. These are easily installed and placed by the workmen.

Because we have an intersection road about every mile we do not concern ourselves with posting detours. On major highways passing through the county we will post a detour; however, these are very limited in number and are not necessary in the one-day closing situation. We will permit local traffic, such as a resident or a farmer needing to

enter the work zone with his farm equipment, to enter the area. Workman will guide him around the work zone as safely as possible, using hand signals, not a paddle. An advanced signal advises that the road is closed with the appropriate black and white sign. In 99 percent of the cases, the traffic under these situations consists of local residents. They know their way around the work zone without being instructed. We have very little cross country traffic in the rural areas. We have not had a reported accident in a one-day closing work zone in my career. Any public property damage that might occur at the location where the sign is placed has been primarily from turning movements, as opposed to people driving through and striking the sign during daylight hours. Even these have been few and very minor in nature.

Closings more than one day require a more detailed treatment than the one-day daylight closing. Advanced warning of the closed highway is absolutely a must. Appropriate black-and-white road-closed or closed-to-through-traffic signs should be placed at the closest intersecting highway to indicate that the road is closed.

A satellite sign placed adjacent is often helpful to advise that a bridge is out or a culvert is closed or some appropriate message indicating the reason for the closing. These signs are placed as close to the intersection as possible to permit construction traffic to enter the areas where the work is being performed while discouraging the through traffic.

The next important structure is the total barricade which should be placed well in advance of the construction site so that there is a recovery zone between the signs, barricade, and obstruction. We use a system of steel barrels painted appropriate construction colors with reflectorized tape and U-channel posts to form a gate on rollers so that it may be opened or closed to permit construction traffic to enter into the work zone. At night this is closed and chained to provide a warning should someone exceed all the signs that have been posted in advance of the closure. Orange and white hash signs placed horizontally across this structure do an excellent job of warning the motorist of the total closure. Another "Road Closed" sign is also installed. If construction materials are used on the site, placing them in the road way beyond this barrier so that a vehicle would have recovery time should they exceed that zone provides a third notification and barrier to vehicles that might have entered the zone.

We have had only one reported accident in the last ten years where a vehicle has passed the advanced warning signs and entered into the zone striking a barrier and driving into the recovery zone. In this case, the barricading wrapped around the vehicle, slowed it to a halt and no further damage occurred other than property damage to the vehicle. It is important that you give as much recovery zone as possible to vehicles entering this zone. However, there are times when work is done close to an intersection where it is absolutely impossible to give a lengthy zone. In this case, best judgement should prevail.

We have been placing a "Stop" sign on the back of the first advanced warning sign

indicating the road is closed. This is standard practice in the State of Ohio, although we have had some criticism from the Highway Patrol saying that they feel as though this provides some conflicting signals. We still think the "Stop" sign should be placed there for vehicles exiting the zone whether they are construction vehicles or local residents living in the area.

Another practice we would like to discourage is signage used by the State Highway Department suggesting to the motorists when they are entering into construction zones that they seek an alternate route. This is done in lieu of posting a detour. This has been especially true of construction done on I-75 through the Findlay-Hancock, Ohio area. The alternate route concept places traffic on highways that are not designed for the volumes that occur when they are used in lieu of detours. We strongly suggest that this practice cease and that described detours be marked and the motorists advised to follow them.

Probably the most important part of closing roads for either one day or multiday purposes is the notification of all emergency and law enforcement agencies. We make a call to the Sheriff's Department which in turn notifies the Emergency Medical Services, as well as all the rural County Fire Services that a road is closed and for whatever specified period of time. We also notify the schools so that the schools that would be driving buses in these areas are aware in advance that the road is closed and that an alternate route will be provided or, in an emergency, they will be permitted to drive through. This is a public relations (PR) call, but it provides for good public information. Many of the people who live in the rural area scan our radio frequencies on a continuing basis. Long closings on major highways include notification to the local radio station and newspapers, as well. These provide adequate warning that certain construction may be occurring in a effort to notify the motorists in advance before they start their daily driving routine. This probably provides more safety and reduces accidents more than any other part of the work zone traffic safety program.

For a small, low-budget highway department arrow boards and message points are desired devices to own but often cannot be afforded. We, therefore, use other traffic control devices in an effort to keep the cost lower. We would rather use plastic barrels properly reflectorized than we would cones, and we also use battery-operated flashing lights. In most cases, we will use an amber face on one side and the red face on the opposite side so that traffic from both directions will get the proper notification. If there is a need in the industry for anything, I think it is in the area of improving the intensity in the type of our battery-operated flashers. It appears to me that they are not nearly as intense as they should be.

Probably the moving work zone that those of us in the northern climates experience in the winter is the one that creates the biggest problems, and to date we have not found adequate solutions. This would be the snow-plowing operation. A snow plow whether plowing, salting, or both is a moving work zone. We have not found a good way of keeping the motorist back far enough behind the plow to allow the proper operation.

Most of our work zone accidents occur when the snow plow reaches an intersection and continues to make a right turn around the intersection in a U-shape fashion in an effort to push the snow off into the shoulder area after he enters the intersection. This action does not present any problems. However, the snow plow then has to reverse the direction turning back into the same direction he has just recently plowed in an effort to align the truck to continue on through the intersection. Sometimes a vehicle will pull up behind the snow plow too close out of the view of the driver's mirrors, and he backs over his hood. Property damage from this action can be very great, although we have not had any personal injuries involved. We operate all the proper vehicle flashers. Our vehicles are all painted the appropriate construction orange and should be readily visible both day and night. However, motorists still will not give the operator the proper courtesy to stop back away from the intersection so that the plow operator can do his work. Some agencies place a sign similar to the fire truck asking the motorists to stay 500 ft behind the plow. However, in plow operations most of the snow curls around to the back side of the truck, sticks on the sign, and makes it impossible to read. Somehow as an industry we need to find a better way of dealing with snow plows so that we can educate the public to give the plow vehicle the respect and space needed to do its work.

I appreciate a rural county engineer being placed on the program to give his perspective on rural work zone traffic protection. I trust this perspective might be helpful to the industry so the rural perspective and the problems related thereto can be taken into account as the industry strives to improve its traffic control and safety devices both for the public and for the worker.

WORK ZONE TRAFFIC CONTROL TRAINING THROUGH REGIONAL TRANSPORTATION ASSISTANCE PROGRAM

Henry W. Sandhusen
Highway Engineer, Office of Highway Safety
Federal Highway Administration

The subject I would like to address today is some of the current resources available for training designers, project engineers and inspectors, and construction personnel in work zone traffic control for rural highways. Most of this material is available to you through the Regional Transportation Assistance Program (RTAP).

BACKGROUND

I would like to see a show of hands from any of you who are familiar with the RTAP Program. If you don't have your hand up, look for your closest neighbors--when you get a chance later, you may want to talk to them about their experiences with these Technology Transfer Centers.

I am not surprised to see only a few hands. I am, however, always a little disappointed because the RTAP has so much to offer in all of the areas related to highway design, construction, and maintenance.

RTAP came about in 1981 when Congress appropriated $5 million to be used by the FHWA to provide technical assistance to rural agencies. The largest of the projects undertaken was the Technology Transfer Program for Local Transportation Agencies (often referred to as the T^2 Program or T^2 Centers).

The T^2 Centers are the basis for the RTAP program and provide a mini-transportation extension service for local agencies. Originally there were 10 centers, but they have now grown to 44, or about one center for every State. These centers are jointly funded by the FHWA and State highway agencies generally through State land-grant universities.

The T^2 Centers can often assist local agencies by providing course instruction, course materials, technical advice, and technical material. These centers are as close to you as your telephone.

WORK ZONE TRAFFIC CONTROL TRAINING

Currently, the FHWA and the North Carolina T^2 Center have developed a work zone traffic control course for training maintenance personnel. This course is titled "Work

Zone Safety for Rural Local Agencies." Don't let the title fool you--the course is basically for improving the skills and procedures used by maintenance crews in setting up and operating short-term work zones. The material is basic to two-lane, two-way rural highway operations. The material is broken up into the following seven video-assisted training modules:

I. Introduction--This involves a discussion of the potential problems associated with short-term road work on two-lane roads.

II. Traffic Control Devices--Provides an overview of the common devices that are required to maintain safe work zone activities on two-lane roads.

III. Traffic Control Zones--This module explains the various parts of the work zone and why they are necessary. The course material also provides a quick reference booklet and a series of work zone problems for use as a training activity.

IV. Typical Applications--This module provides training in the setup, operation, and takedown of typical maintenance work zones.

V. Flagging Operations--This is an excellent module which can also be used separately to explain good flagging procedures for common maintenance activities.

VI. Legal Liability--Provides, in story format, the importance of following procedures and using good practices to protect the agency from potential liability suits.

VII. Summary--Summarizes and reinforces the important points of all the previous modules.

This total training package, when taught with an instructor and including the workshops, requires a day. The material can also be taught as separate sessions, or the video portion can simply be shown.

I would like to recommend to you the use of this material in training maintenance personnel and other crews, such as survey crews who will be exposed to traffic. Although the material was prepared for local agencies, I believe it would be excellent for use by State agencies for training their own personnel.

It is FHWA's intention also to make this course available through the National Highway Institute (NHI).

OTHER WORK ZONE TRAFFIC CONTROL TRAINING AIDS

I would like to end by mentioning some of the other work zone material that is available for training. Training materials include the following:

- NHI course, "Design and Operation of Work Zone Traffic Control."
- NHI Course No. 13355, "Transportation Alternatives During Highway Reconstruction."
- ATSSA Course, "The Thin Orange Line."
- ATSSA flagman training pocket guide and video.
- Special RTAP efforts in Iowa and Michigan with circuit-rider training.

PUBLIC AWARENESS OF WORK ZONE ACTIVITY

Lynda J. South, Manager
Office of Public Affairs
Virginia Department of Transportation

Safety in highway construction and maintenance work zones has become a growing concern for transportation agencies around the country. The American Association of State Highway and Transportation Officials' (AASHTO) Subcommittee on Public Affairs promotes the development of public awareness programs to focus attention on driving safely through highway work zones. For the past five years, work zone safety public awareness programs have been a focal point of the annual National Transportation Public Affairs Workshop sponsored by AASHTO. An outgrowth of that focus is a newsletter that reports on State DOT's public awareness activities to promote work zone safety. In conjunction with the newsletter, an informal survey was conducted in December 1990 to determine the types of public awareness efforts under way. Some of the findings from the survey are presented below.

Four years ago, only a few States had started public awareness efforts. Today, 29 State DOT's have public awareness initiatives underway ranging from limited efforts including periodic traffic-alert news releases to comprehensive programs involving public/private partnerships. Another four States plan to start programs within 1991.

The common thread that links most of the public awareness efforts is the increased notice to the public of construction and maintenance activities. The belief is that an informed driver is a less hostile driver when it comes to knowing about work that might affect travel plans. This notification includes issuing traffic alert news releases, helping develop and contributing to traffic alert columns in daily newspapers, developing and distributing maps showing areas affected by highway work, and improving communication with traffic reporters.

The survey showed that the vast majority of the States use some form of the "Give 'em a Brake" slogan. A few States use other slogans, but AASHTO strongly encourages use of the "Give 'em a Brake" slogan to convey a cohesive national safety message.

More than two-thirds of the States with active campaigns rely on Federal and/or State safety grants. California was one the first States to develop a campaign using Federal highway safety funds. CALTRANS' campaign has become a model for other States that have adopted its "Give 'em a Brake" slogan. California's campaign emphasizes use of free billboard space, brochures, bumper stickers, driver tip cartoons, and material for high school driver training classes. The campaign was broadened to include all road workers in both the public and private sectors, and it has reached every Californian several times over.

WORK ZONE SAFETY PARTNERSHIPS

Effective public awareness campaigns that can change human behavior share certain characteristics. They employ one message, have support from several groups or organizations with a mutual interest in an issue, and use various mediums to sustain the message over a long time. For this last reason, partnerships are particularly effective because they can provide more resources to keep the safety issue before the public.

CALTRANS was the first State agency to involve private sector partners in its campaign. For example, Mobil Oil and Chevron mailed two million envelope stuffers with the "Give 'em a Brake" message in their monthly bills. The 3M Corporation printed the message on 15,000 large stickers placed on the back of CALTRANS' and contractors' road-building equipment.

Many State DOT's have developed and implemented public awareness campaigns capitalizing on California's experience and have sought partners to promote their work zone safety message. Examples include the following:

- Utilities strongly support Oregon DOT's efforts with the campaign slogan "Oregon Road and Utility Workers--Give 'em a Brake." The logo appears on bumper stickers, litter bags, brochures, and lapel pins. The various utilities helped pay for and distribute the materials. In addition, dairies ran the logo on milk cartons, and two grocery stores used it on carry-out bags.

- The Michigan DOT along with several other States used California's experience to secure free billboard space from their State billboard associations to display the "Give 'em a Brake" message. With the help of the Michigan Road Builders, Michigan DOT obtained 110 billboards through the State for varying lengths of time. Michigan also distributed 60,000 "HELP" cards describing the work zone speed law at its Welcome Centers, and they distributed 20,000 work zone posters, including some 2,000 to trucking firms.

- Virginia's DOT worked with the Virginia chapters of the American Automobile Association (AAA) to distribute more than 300,000 work zone safety brochures a year through AAA's TripTik vacation maps. The brochure educates drivers about the necessity of highway maintenance and construction work, answers questions about construction practices, and encourages safe driving in work zones.

- North Carolina's DOT recently made a major commitment to increase the public's awareness. This past year $190,000 was earmarked for a new program that includes the production and purchase of air time for public service radio spots, promotional items, printed materials, and an in-house training program. The contractors' association supports NCDOT's efforts and is undertaking a fund-raising campaign to collect money for the program in 1991.

- Pennsylvania's DOT illustrates a partnership of a different type. After determining that most of Pennsylvania's work zone safety accidents involved men between 21 and 35 years of age, PennDOT teamed with the Pittsburgh Pirates last summer to produce radio and television public service announcements targeted to young males. In addition, the Pirates ran "Give 'em a Brake" scoreboard messages during games. A few years ago, Minnesota and Michigan DOT's produced similar, successful public service announcements featuring football, soccer, and hockey players.

CAMPAIGN COMPONENTS

Let's take a closer look at just some of the innovative tools State DOT's use to get the work zone safety message before the public:

- Moving Billboards--New Jersey's DOT gets credit for this creative idea--"moving billboards." It installed high-intensity reflective signs on 600 of its trucks asking motorists to give highway workers a brake. The signs cost approximately $100 each and feature a brake pedal to reinforce the message of "Slow Down."

- Cartoons--Mississippi uses cartoons featuring animated motorists, the "Give 'em a Brake" slogan, and messages of "Slow Down" and "Be Alert." The cartoons were sent to 250 daily and weekly newspapers. The Mississippi Highway Department reports excellent use by the media.

- Newspaper Ads Featuring Highway Worker--Newspaper ads picture dedicated highway workers giving a personalized plea to watch out for them and their coworkers. Nebraska and Virginia use this technique to recognize employees for their good work while reminding readers that the people they pass in highway work zones could be their friends or neighbors. The "Give 'em a Brake" logo in the ads helps reinforce that theme.

- Project Signs--Many States are placing special signs just ahead of major projects to remind drivers of the work zone safety message. Some States have placed "Highway Workers--Give 'em a Brake" signs at rest areas, truck weighing, and inspection stations.

- Metered-Mail Messages--"Highway Workers . . . Give 'em a Brake" appeared on approximately five million envelopes sent out during the summer by Michigan State agencies and insurance companies. The cost to Michigan DOT, which organized the effort, was $1,100 for 33 postage meter "slugs." The message also appeared on mailing envelopes sent out by Michigan's AAA and the agency that handles driver licenses and vehicle registrations.

- Radio Advertisements--Many States send work zone safety public service

announcements to radio stations. Most request free air time for these safety messages and have varying degrees of success; however, Oklahoma DOT has chosen another route. It has developed an agreement with the Oklahoma Association of Broadcasters to get the radio and television stations on their side. The DOT pays the broadcasters' association to distribute the PSA's to stations and evaluate their use. In the first three months of the contract, the DOT received a 10:1 return on money spent. While a few of the stations run the spots during off-hours, many stations are airing the PSA's during prime morning and evening drive time and early evening hours.

- Driver Education--A few States have targeted inexperienced drivers. Virginia and California developed videos and accompanying educational materials for driver education classes. In the last school year, Virginia's DOT reached 95,000 students with its video, distributed by the State's department of education. For children in kindergarten through sixth grade, Minnesota's DOT hired a team of teachers to develop "Play it Safe"--a work zone and snow plowing safety module. The module includes a 45-page activities manual that teachers use to introduce the importance of work zone safety. The DOT is having a module developed by St. Cloud University on "What's your Orange IQ?" aimed at beginning and defensive-driving students.

CONCLUSION

In the 1990's, it will become more important than ever to increase our efforts in the public awareness area. An aging highway system means more and more rehabilitation under heavy traffic conditions. It is imperative that the different disciplines within the transportation community--traffic engineering, location and design, and the field offices that supervise construction and maintenance activities--work with their agencies' public relations professionals. It is their job to inform the public about potential work zone problems--how well they do their jobs depends on the quality and timeliness of the information they receive.

It also is essential that State transportation departments, local public works departments, highway contractors, and State and local enforcement agencies work together to provide a united front in getting and keeping the work zone safety issue on the motoring public's safety agenda.

INSPECTION OF WORK ZONE TRAFFIC CONTROL HARDWARE

A SYSTEMATIC APPROACH

Donald L. Woods
Professor of Civil Engineering
and
Research Engineer
Texas Transportation Institute
Texas A&M University

John N. Lipscom
Training Specialist
Texas Engineering Extension Service
Texas A&M University

NEED FOR A CHECKLIST

Inspection of the hardware used in construction and maintenance work zones frequently reveals devices that were not properly installed or maintained. It is easy to place the blame on poor workmanship on the part of the contractor's personnel or inadequate inspection on the part of the agency personnel. While both of these points are valid to a degree, they represent only a part of the total problem. It is important to look beyond placing blame for the inadequacy and toward practical ways of minimizing the possibility of improper installation and maintenance of construction and maintenance work zone hardware. This paper suggests a direction for the effort to accomplish this goal.

Anyone who has ever been an inspector on a construction job knows the frustration of the beginning inspector. The first inspection job is utter confusion. There are so many details to check and so little time to review the manufacturer's recommended installation and maintenance guidelines that many little things get overlooked. Even if the beginning inspector catches a defect, often the contractor's strong arguments, combined with the inspector's lack of confidence results in the defect not being corrected. In the past, the highway industry reduced this problem to a minimum by having the novice inspector tag along with an experienced inspector for several weeks before turning him or her loose alone. The shortage of personnel and the ever increasing complexity of the hardware used to protect the motoring public and construction and maintenance personnel have made the old methods largely obsolete. Obviously, even an experienced inspector cannot teach the critical items to inspect if he or she has no experience with that device.

Poor installation and maintenance is costly, both to the contractor and to the public agency. The sophisticated hardware commonly used today is designed to require minimal maintenance. Improper installation and maintenance can result in substantial damage to the hardware, which must be replaced. This replacement is costly to the contractor. While this may not change the cost of that particular job, the contractor will surely increase the cost in the next bid based on experience on that job. Ultimately the contractor's insurance increases due to adverse court decisions following accidents with hardware. Additionally, the agency must defend itself in the litigation even when the

contractor is found negligent or the defendants are found to be innocent. Remember, a case that goes to trial costs the agency $40,000 to $50,000 in litigation costs alone. The point simply stated is, poor installation and maintenance of construction or maintenance work zone hardware is expensive.

PURPOSE OF THE CHECKLIST

The checklist serves four fundamental purposes. These are:

- To assist the beginning inspector (agency or contractor) in conducting a meaningful inspection of the hardware.
- To assist the contractor by telling him or her precisely what items are to be inspected and what is expected on each item.
- To avoid costly oversights by agency or contractor personnel.
- To reduce the number of potential legal cases and the magnitude of the losses in cases filed by reducing the severity of the impact with the hardware.

Obviously, to achieve these objectives, the checklist must be used. There are two very critical aspects of using the checklist. First, management must be committed to the use of the checklist by all inspection personnel. The key to any approach to reducing the problems identified is getting the management personnel to insist that it be part of the agency and, therefore, the contractor's routine practice. The second factor is training inspection personnel to understand why each of the recommended details is important. Often field personnel do not see the difference between high strength bolts and bolts of similar size which they happen to have available. In an impact the difference can be $24,000 on a G-R-E-A-T™ CZ crash cushion.

The training emphasis should focus on, "We want to do this," and "Here's why we want you to do this." A full two-day course has been prepared based on the checklist to assist those doing the training. Copies of the course training manual are available from:

The Texas Engineering Extension Service
Attn: Barbara Moyer
Henderson Hall
Texas A&M University
College Station, Texas 77843

The training manual includes copies of the relevant State's typical working drawings of the hardware included in the checklist for ready reference. The checklist is formatted in a pocket-size document for ease in carrying in the field.

One of the key aspects of using the checklist approach that is sometimes overlooked is the power of the argument, "You knew exactly what was expected," when the contractor believes the change is not worth the time and effort.

BASIS OF THE CHECKLIST

The original concept of need was a realization on the part of Texas State Department of Highways and Public Transportation and the Federal Highway Administration Division safety personnel that they were repeatedly observing major and minor problems with the installation and maintenance of safety hardware in the field. The Texas Engineering Extension Service (TEEX) was requested to prepare a course to train department personnel on the proper installation and maintenance procedures for construction and maintenance zone safety hardware. TEEX worked cooperatively with Texas Transportation Institute staff to prepare the course. It soon became apparent that there were so many things to check that no reasonably competent person could be expected to remember all the items. The complexity and variety of commonly used hardware simply made the task too enormous for the human comprehension. The checklist evolved from that realization.

The items selected for inclusion in the checklist were developed by cooperative discussions between personnel involved in field inspection and experienced staff members, as well as persons in other States with experience with common field problems with safety hardware. The first draft of the checklist included questions which had correct answers of "yes" and correct answers of "no". Thus, the user had to be familiar with the details in order to know if the installation was proper or was not proper. The checklist was rewritten to insure that all questions were phrased to be answered "yes" if correct and "no" if the installation was not correct. Thus, by comparing the checklist items with the field hardware, the user will immediately know if the installation is correct or incorrect.

The final step in the preparation of the checklist was the field validation of the checklist items. The clarity of the checklist questions and the completeness of the checklist items were the primary concerns in the field testing. Several items were added and many questions were rephrased as a result of the field trial. Subsequent use in the field has produced mixed reactions. The most experienced inspection personnel and those newly involved in inspection of traffic-control zone hardware react very positively. The senior persons recognize the need to develop the skills of the beginners. The beginners feel the frustration of attempting to learn a great deal in a brief period. Those in between typically feel it is more of a nuisance than a help.

ADAPTING THE CHECKLIST TO YOUR NEEDS

The checklist was developed specifically for the State of Texas. It reflects many of its unique practices. Therefore, the first step in adapting the checklist to your needs is a detailed review of the items addressed in the checklist to determine which do not apply in your State. Additionally, a list of the safety devices used in your State which are not included in the checklist should be made. The items you do not need should be deleted, and the additional items should be added to the checklist.

Following identification of the items you need in the checklist, the questions associated with each item must be carefully reviewed. Are they the appropriate items and phrased appropriately for the personnel in your State? Regional differences do make a significant impact. If the field personnel do not understand the questions asked, the effectiveness of the checklist will be diminished. For the new items you have added, a series of questions must be formulated to insure that all relevant features of the hardware have been inspected when the checklist questions have all been answered. When the checklist is essentially completed, try it on a few jobs to determine how well it meets your perceived needs. A few revisions will probably be necessary to make it fully functional.

The final part of adapting the checklist to your State's need is the provision of a training program to emphasize management's desire that the checklist be used by all field personnel. This opportunity should also be used to explain why the features in the checklist are important and need to be installed correctly. Don't overlook the fact that in tort litigation, the primary issue is often the simple fact the device was not consistent with the agency's own guidelines. That leaves the jurors thinking that as an agency they do not know what they are doing because they can't seem to follow their own guidelines. The jurors see an injured plaintiff, and with doubt about the agency practices, the jury is likely to award a judgment to the plaintiff.

TIPS ON EFFICIENT WAYS TO INSTALL AND MAINTAIN HARDWARE

The goal of every highway agency is to use the funds available in the most efficient manner possible. With this in mind, a few cost-saving items have been developed for more efficient installation and maintenance of construction and maintenance zone safety hardware.

Where drainage is required under the temporary concrete safety shape, two procedures have been used to provide the water path without adversely affecting the barrier crash worthiness. One is to have the temporary concrete barrier sections cast with drainage slots on the bottom. Two openings about 18 in long are usually sufficient for 10-ft segments. The second method is to use a pavement grinder to grind an opening in the pavement 1/2 in deep by 12 in wide by 26 to 28 in long at three points along the barrier section. The loss of lateral support is not significant. However, the connection

between sections becomes much more critical as more of the load must be accommodated by the connection.

Filling the inertia crash cushion with sand is a tedious and time-consuming task. More critically, the personnel are working in a high-risk environment for an extended period of time. One method that has been successfully used is to set up the plastic containers with their associated diaphragms and then bring a concrete mixer truck loaded with dry sand out to fill the containers. A little hand work is required to top out the sand in each container, but the overall time at the site is greatly reduced.

The G-R-E-A-T™ CZ crash cushion is being used with increasing frequency in construction situations due to the relatively narrow width, proven crash worthiness, and its flexibility to be used at other locations. The maintenance of a damaged G-R-E-A-T™ CZ crash cushion is time-consuming, and the work is usually accomplished in a high-risk environment. One very successful method to reduce the maintenance time to minimum is to erect the G-R-E-A-T™ CZ on a concrete pad that is equipped with lift point anchors to accommodate a threaded eye. The damaged unit is lifted from the site, including concrete pad, and sent back to the contractor's lay-down area for repair. A second G-R-E-A-T™ CZ unit kept in reserve is installed at the site. The installation is accomplished in less than 30 minutes and the detailed repair is accomplished in a much safer work environment.

A similar strategy is used with the steel-drum crash cushions in a temporary situation. Using modular units, the damaged section can be removed quickly and the new module inserted in the system rather quickly. Steel-drum crash cushions cost about one-fifth of the cost of a G-R-E-A-T™ CZ and about the same as the sand-filled inertia crash cushion. They can be used effectively in temporary situations where they would not otherwise be attractive due to salting of the roadway in the winter months.

Roadside signs mounted on a steel U-post are commonly used in construction and maintenance work zones. However, driving the full length U-post is a difficult task due to the height above the terrain where the work must be accomplished. Several States have reported that driving a stub U-post to the appropriate depth and bolting the post to the stub post is much more efficient. The same requirements exist for the U-post that exist for permanently mounted U-post signs. Additionally, the stub post should extend more than five inches above the terrain.

The dynamic nature of construction and maintenance work zones dictates that a constant checking of the adequacy of the safety hardware be a routine part of the construction and maintenance work program. It is not necessary that an inspection of every piece of hardware be done every day. But certainly after a piece of hardware has been damaged and repair was required, a rather detailed inspection is in order. Each time a detailed inspection is carried out, a record of that inspection should be made. The daily diary is the usual documentation of the inspection. It is wise to indicate that the checklist was used, if indeed it was, so that when a question arises concerning what type

of inspection was conducted, you can refer to the items on the list. This may well be the cost-effective element of the checklist. It eliminates the doubt about what was done and provides positive documentation that the agency was doing the job in a systematic and logical manner.

CLOSURE

The checklist does not replace the need for using good judgment during inspection. Without a detailed inspection, the checklist is essentially useless. It is helpful in insuring that critical items are not overlooked and in documenting the nature of the inspection actually conducted. The complete training document contains the typical guideline sheets which are applicable as ready reference when the individual has a question about how something should be done. Typical sheets are included in Appendix B of this paper. Appendix A is the checklist currently used in Texas. These materials are provided to illustrate how one State has implemented the checklist.

The checklist approach provides a complete, systematic approach to inspecting construction and maintenance work zone hardware. Properly used it can reduce the cost of highway construction or maintenance.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the Texas State Department of Highways and Public Transportation personnel who participated in the discussions during the development of the course from which the checklist evolved. We are especially appreciative of the foresight, encouragement, and contribution to the body of materials and slides provided by Mr. Greg Schertz, Federal Highway Administration, formerly of the Texas Division, and now safety engineer with the Denver Regional Office. Without Greg's concern and encouragement, this effort would likely not have been undertaken and certainly would not be as successful as it is. The support of Mr. Nelson Evans, Public Works Training Division of the Texas Engineering Extension Service, is also gratefully acknowledged.

WORK SITE TRAFFIC CONTROL TRAINING AND CERTIFICATION

Victor H. Liebe
Director of Education
American Traffic Safety Services Association

This presentation, I am subtitling "The Binder", or the adhesive, if you will. That's the "**stuff**" that holds all the issues that the previous speakers at this conference have presented, together. This paper addresses the need for education and training of personnel in work site traffic control, the ingredient without which all of the other elements, such as standards and guidelines, techniques, and "state-of-the-art" devices, are worthless.

Traffic control at highway work sites must be implemented as a system in order to be effective. All traffic control systems must accomplish the following if they are to be considered effective: They must provide adequate warning that driving conditions are going to change at some distance ahead. They must give sufficient information about what lies ahead (what is going on). They must provide instructions about movements that will be required. And then, they must provide clear guidance to the motorist by outlining the path to follow into, as well as past, the work zone. The objective is to prepare the motorist properly to enter the traffic control zone and then provide a safe travel path past the affected area. The ultimate goal is to separate the moving traffic from the activity area so the workers can do their construction or maintenance job without conflict or incident with the motorist.

More and more frequently today the news media are reporting stories that read in part like this:

- "Five-vehicle crash on 401 near Toronto takes the life of an MOT highway worker performing maintenance."
- "Virginia DOT supervisor killed, five seriously injured in highway motor vehicle accident."
- "Local husband and wife both killed one year apart in motor vehicle accidents while on highway construction jobs."
- "Four die while coring pavement near Bloomington. Driver of striking vehicle says **'I never saw them.'**"
- "Utility worker steps into path of moving traffic from behind work truck. Killed instantly."

I'm not suggesting that in any of the instances cited here that there was inadequate traffic control in place. On the contrary, let's assume the traffic control was adequate. Instances like these continue to be repeated daily throughout the country, and in 1989 nearly 800 persons lost their lives in work zone accidents, motorists as well as workers! Additionally, approximately 29,000 disabling injuries result from work area collisions, and the number of property damage incidents is at an unheard of high.

What can be done to change this pattern of carnage, given that minimum standards exist, traffic control techniques and procedures are known, and a variety of good devices is available?

- First, it is necessary for persons who are responsible for traffic control to know and understand all of the minimum standards and guidelines for traffic control in work areas.

- Second, traffic control devices that meet, and in fact exceed, the minimum standards must be utilized at work sites, **AND** the devices must be maintained in good condition throughout the life of the project.

- Third, the traffic control system must be designed using the known and tested traffic control techniques and procedures.

- Fourth, in my opinion, the keystone that holds these building blocks together is the need to provide a minimum level of education and training to those responsible for each phase of the traffic control system. This includes the design, installation, inspection, maintenance, modification, and removal of the system.

I'll be a little more specific. Persons responsible for traffic control at work sites **MUST** have education and training in the following subjects:

- Hazards at Work Sites/Need for Traffic Control--Workers who are exposed to traffic adjacent to their work area need to know just what degree of hazard they are being exposed to on their jobs. They must also understand the importance and need for traffic control that meets the requirements of the job for personnel safety.

- Manuals and Standards--A good working knowledge of the standards, specifications, and guidelines is essential to providing uniform, effective traffic control plans. Such knowledge and understanding must include, not only what the documents say, but also what they <u>mean</u>.

- Traffic Control Devices--An individual must know the answers to the following questions in order to design and maintain effective traffic control zones: What devices are approved for use? What are their specifications? What is their *intended* use? What does the motorist perceive when encountering these devices?

- Location and Placement of Devices--Even the best devices available may be ineffective if not properly located and placed. One must realize the importance of **pattern** that the combination of the device, its location, and placement presents to the motorist.

- Typical Layouts--In order to promote uniformity in the treatment of the most common highway work sites, a person must know how to apply the appropriate typicals shown in the standard references. Application of these typical plans tends to promote uniform motorist response.

- Motorist Characteristics--Knowing traffic control device specifications and placement does not ensure a good traffic control plan. Knowledge of how the driver, as a human being, obtains information, interprets it, and then reacts to it, is critical if the plan is going to have any chance of working when in place out on the job.

- Options and Alternatives--In most cases with highway construction/maintenance jobs, conditions will be anything but "normal." A traffic control person must have a number of "tricks" available in order to handle these non-normal situations.

- Installation and Removal of the Traffic Control Zone--Often, the most dangerous time period for a traffic control person is during the installation or the removal of the traffic control devices. A firm understanding of the correct procedures and techniques will increase a person's chance of survival significantly.

- Inspection and Maintenance--The traffic control zone must be effective as long as it is in place. In order to keep it effective, one must have a good inspection plan and then follow it up with an equally good maintenance program. Without such knowledge on how to set up and conduct these programs, the effectiveness of the zone is jeopardized.

- Legal Liability and Record Keeping--Good risk management is nothing more than knowing what risk to accept. A firm understanding of the legal aspects of one's job will often help define the limits of that person's activities. Additionally, making and filing of good records of a person's activities is also critical, should it become necessary to justify one's work.

- Flagging Operations--During the conduct of the job, it is sometimes necessary to interrupt the traffic flow in order to accommodate a work activity or to provide a little more protection for everyone. If the proper flagging procedures, equipment, location of flagger, and flagging techniques are not selected and used, a crisis is invited. Advance training can reduce this potential for crisis.

- Emergencies--Situations arise in construction/maintenance work areas which sometimes call for instant reaction by workers who may be present. A basic

knowledge of how to react in a crisis can often make a difference between a manageable versus an out-of-control situation.

Training in the above listed areas, as a minimum, must be provided for all traffic control persons before they can attempt to provide even the *least* amount of protection at the work site. After such training, in using their common sense, a person should be able to solve relatively simple traffic problems. However, it takes a lot of on-the-job training before one can fully understand just what good traffic control is.

The American Traffic Safety Services Association (ATSSA) provides a program of instruction that addresses these exact topics. The course is presented over a three-day period, which includes not only a course of instruction, but training as well through a series of "hands-on" workshops. The workshops provide the participant with actual, supervised exercises in traffic control design techniques. Over 6000 individuals have completed the ATSSA training course.

ATSSA also has a program for certification of those persons who have supervisory responsibilities, or technical duties, involving work site traffic control. Depending upon one's experience, a person can become certified as a "Supervisor" or as a "Technician." Over 2000 individuals have become certified through this program. The Certification Board is comprised of professionals from the Federal Highway Administration (FHWA), the Institute of Transportation Engineers (ITE), and ATSSA. The certification program does not guarantee the proficiency of an individual in performing work site traffic control functions, but it does recognize those who have a basic level of education and a minimum amount of experience in that discipline. Each applicant is considered on the merits of his or her own level of achievement.

In summary, we have standards and guidelines established which are updated and revised to meet the current needs. We have an array of traffic control devices available with more new things coming into the market each year. We have time-tested techniques and procedures with continuous research revealing new ways all the time, and we have the training resources. All of these elements must be considered and integrated if the accident rate in highway work sites is to be reduced. Training is the **BINDER** that holds all the other elements of good traffic control together!

MANAGEMENT OF WZTC – MAKING IT WORK!

Johan J. Bemelen
State Traffic Engineer
Colorado Department of Highways

My presentation is primarily about three programs dealing with work zone traffic control currently used in the Denver Metropolitan Area. All three programs are aimed at providing improved traffic control in our work zones. The programs are:

- Traffic Control Review Program
- I 25/I 70 Traffic Control Support Program
- Public Relations Program

The Denver Metropolitan Area is like any other major urban area. There is a tremendous amount of construction going on (1989--$90 million, 1990--$180 million). In addition to the numerous construction projects, we are also dealing with the highest traffic volumes in the State, a great variety of contractors, subcontractors, and suppliers, and work-hour restrictions both during daytime and nighttime.

TRAFFIC CONTROL REVIEW PROGRAM

A little over 2-1/2 years ago, the district construction staff considered a new program called "Traffic Control Review Program." It has been real successful.

The Denver Metropolitan District was experiencing some problems with uniformity of inspection of traffic control devices used in construction work zones. This is not difficult to understand with the numerous projects, engineers, technicians, and inspectors involved. To come up with a solution, the district construction engineer formed an ad hoc committee, consisting of construction and traffic personnel.

The program this ad hoc group came up with involves a district-wide construction work zone reviewer. The program was set up to insure consistency on all projects and relieve some of the duties of project people by providing quality inspection and assistance. You can well imagine that initially this person was not necessarily liked by all residents and project engineers, not to mention the contractors, subcontractors, suppliers, rental companies, our own maintenance crews, and others involved in traffic control. But after getting the initial bugs out of the system and gaining everyone's confidence and trust, the position has really been accepted now. The way the program works is to rotate a new person into this job each calendar year. Starting January 1991, we are on our third reviewer.

Basically, the program takes a project-engineer level person from the district construction engineer's staff. This person has to be interested in traffic control, must be highly motivated, must have had training in traffic control through special classes, and must have developed a certain level of expertise in work zone traffic control.

When formulating this program, the first thing the ad hoc group did was:

- Identify existing problem areas and problem items.
- Develop a system to inspect and rate projects.
- Develop a system to track the items.
- Develop a follow-up system to correct any deficiencies.

The reviewer's duties include:

- Conduct formal inspections (night and day).
- Rate the various major items.
- Do follow-up inspections.
- Chart progress of corrections to be made.
- Provide feedback to the contractor and engineering staffs.
- Make arrangements to train project and maintenance people in work zone traffic control.

The ad hoc group identified about 9 or 10 problem areas, depending on the scope and complexity of the project. They include:

- Method of handling traffic.
- Traffic control supervisor.
- Flagging.
- Signing.
- Lane closures.
- Other work zone devices.

- Short-term pavement markings.

Naturally, not all the areas nor all the items are evaluated, at the time of each inspection or on each project. The reviewer rates each applicable area in a simple yes/no format. Following are some specific items looked for in each area:

Traffic Control Supervisor (TCS)

- Is the TCS properly certified?
- Is the TCS certified as a flagger by the department?
- Does the TCS have a copy of Part VI of the MUTCD?
- Does the TCS have a copy of appropriate standards?
- Are the TCS diaries current and on file?
- Does the TCS have temporary signing removed when not applicable?
- Does he adequately supervise flaggers?

Flagging

- Does the flagger have a current flagger card?
- Is the flagger appropriately dressed?
- Are proper flagging methods used?
- Is the flagger positioned properly?
- Is the flagger station properly illuminated?
- Is the stop/slow paddle reflectorized?

Construction Signing

- Do all the signs conform to MUTCD?
- Does the signing conform to approved method of handling traffic (MHT)?
- Are the signs clean?
- Are they placed correctly?

- Do they display the correct information to fit the construction activity?
- If not in use, are they stored outside of "clear zone?"
- Are the signs fabricated with high brightness sheeting (warning signs only)?

Lane Closures

- Is the lane closure per MUTCD guidelines/standards?
- Is the lane closure in accordance with the MHT?
- Is the taper length correct?
- Are the correct number of channelizing devices being used?

Each year when a different person is put in charge, that person brings with him some new and fresh ideas. This year's person basically did two things differently. He put more emphasis on the positive things he found and included more narratives in his ratings rather than a simple yes or no. He also changed the flagging test; not only were the questions changed, but also part of the test now includes a mandatory viewing of a Washington Department of Transportation video. Figures 1 and 2 show a couple of typical bar graphs used to chart the findings.

We feel the program has really worked well for us, and we will continue to use it. One of the things that has made it a big success is the fact that the person doing the reviews is directly responsible to the construction engineer, who not only initiated the program, but also has been solidly behind it. FHWA likes this program real well, and wants us to look at expanding it in other areas of the State.

I 25/I 70 TRAFFIC CONTROL SUPPORT PROJECT

Another new program we are now involved in, which has been in effect for about one year, is modeled after the very successful traffic control project we have had on I 70 in Glenwood Canyon for a few years now. This one is in the Denver metro area and is known as the "I 25/I 70 Traffic Control Support Project" (TCSP).

Some of the big differences between this project and the Glenwood Canyon project are:

- An urban environment with very large traffic volumes (300,000) instead of a rural environment with low traffic volumes (8,500).
- Many more prime contractors, subcontractors, etc.

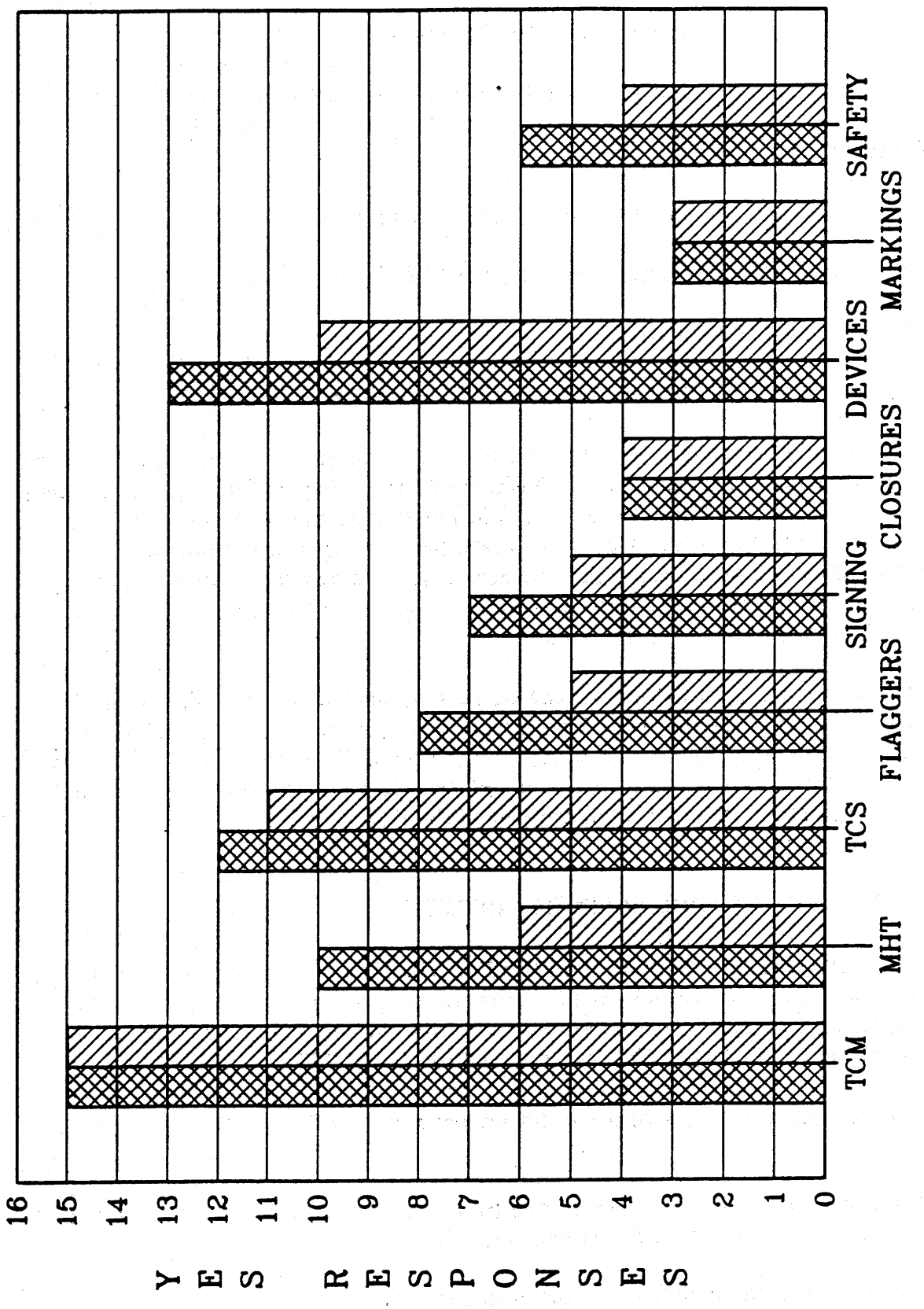


Figure 1 - Traffic Control Review - IR 225-4(38) I 225 at Sand Creek

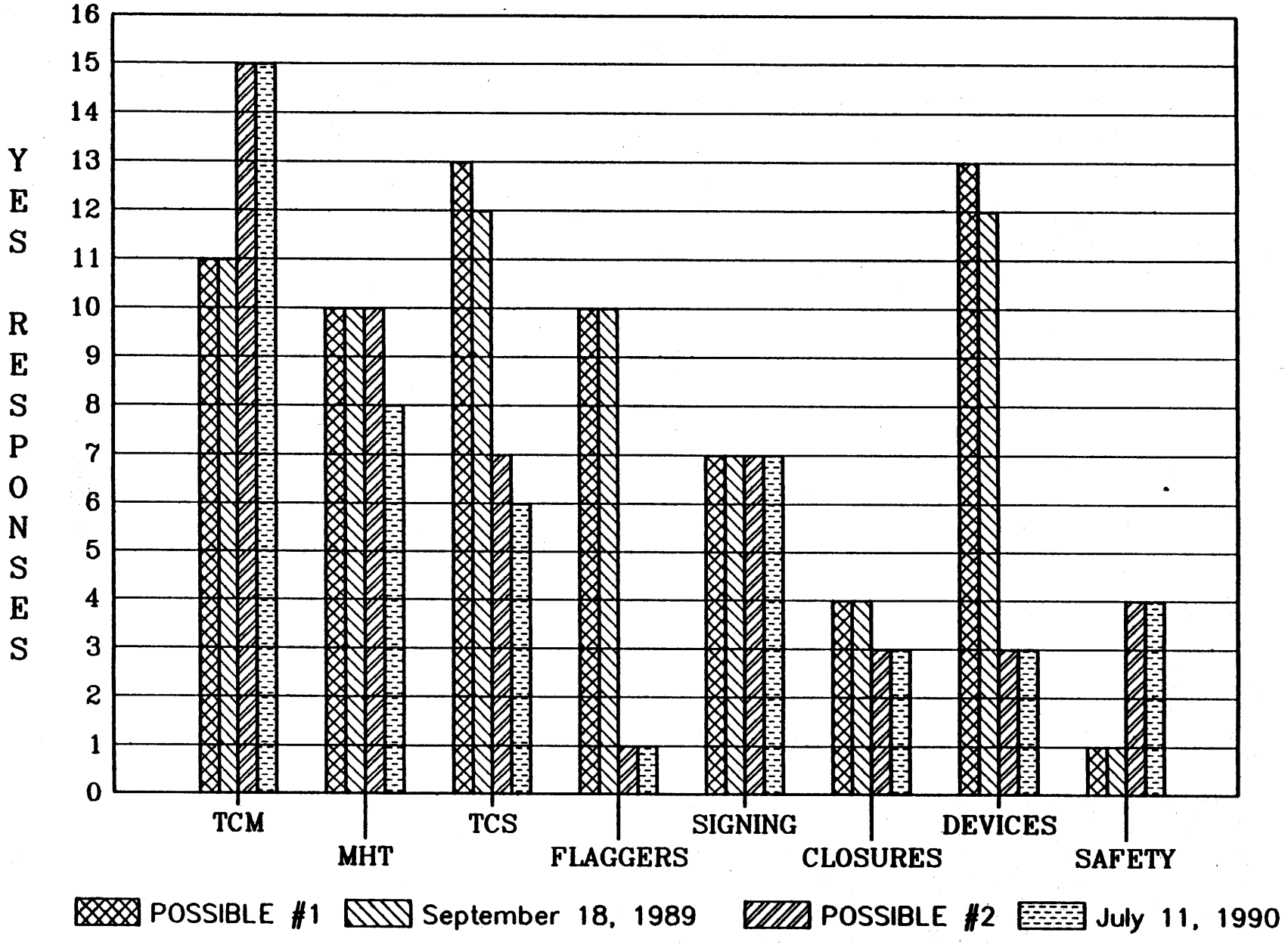


Figure 2 - Traffic Control Review - Dartmouth and Hampden at Sante Fe

- Numerous detours and lane closures that are different every day, whereas in Glenwood Canyon, it is the same every day.

- A 24-hour operation.

The project basically is a traffic control support project and provides for flagging, traffic control supervision, uniformed traffic control, and all traffic control devices, such as changeable message signs, signing, barricades, cones, barrels, and vertical panels for all projects in the identified corridor.

The contractor works under the direction of the Valley Highway Traffic Coordinator (VHTC), who is the department's project engineer. See Figure 3 for organization set-up.

During 1990, this contract involved three major projects at or near the I 25/I 70 interchange. However, this year's project includes at least eight major projects. Additional projects, both by the Highway Department and Regional Transportation District, are expected to get underway during the one-year project period. The eight projects include modification at two major interchanges, two minor interchanges, two Bus/HOV lane projects, a railroad structure, and an overpass.

The contractor is to coordinate with the project engineer and agents of all those contracts (eight or more) to assure adequate traffic control. In addition, the contractor has to provide traffic control personnel and traffic control devices for department maintenance operations and emergencies in the corridor.

Last year's project ran from March 1, 1990 to December 1, 1990. We now have a new contract which runs through December 31, 1991. It was just awarded at a total bid cost of $1,724,275.

All contractors covered by this support project are responsible for assuring that operations, which affect traffic, are not performed without proper traffic control being provided by the support project.

A unique feature we have added to the majority of projects in the Denver area is that in the event there is a violation of the working-hours limitation, the contractor will automatically be subject to a stop-work order to be imposed at the beginning of the next working day. In the event more violations take place, there will be a price reduction for each incident. Price reductions start at $150 per event and escalate to $1,200 after the fourth incident.

As far as the support contractor is concerned, because he is heavily dependent on the construction contractors, he is allowed 30 minutes for removal of detours and closures after the construction contractor completes his work. The traffic control contractor works with the superintendents to assure that traffic control is provided as needed and without conflict between the needs of the various contractors and agencies. This is not

I 25/I 70 TRAFFIC CONTROL SUPPORT PROJECT
ORGANIZATIONAL CHART

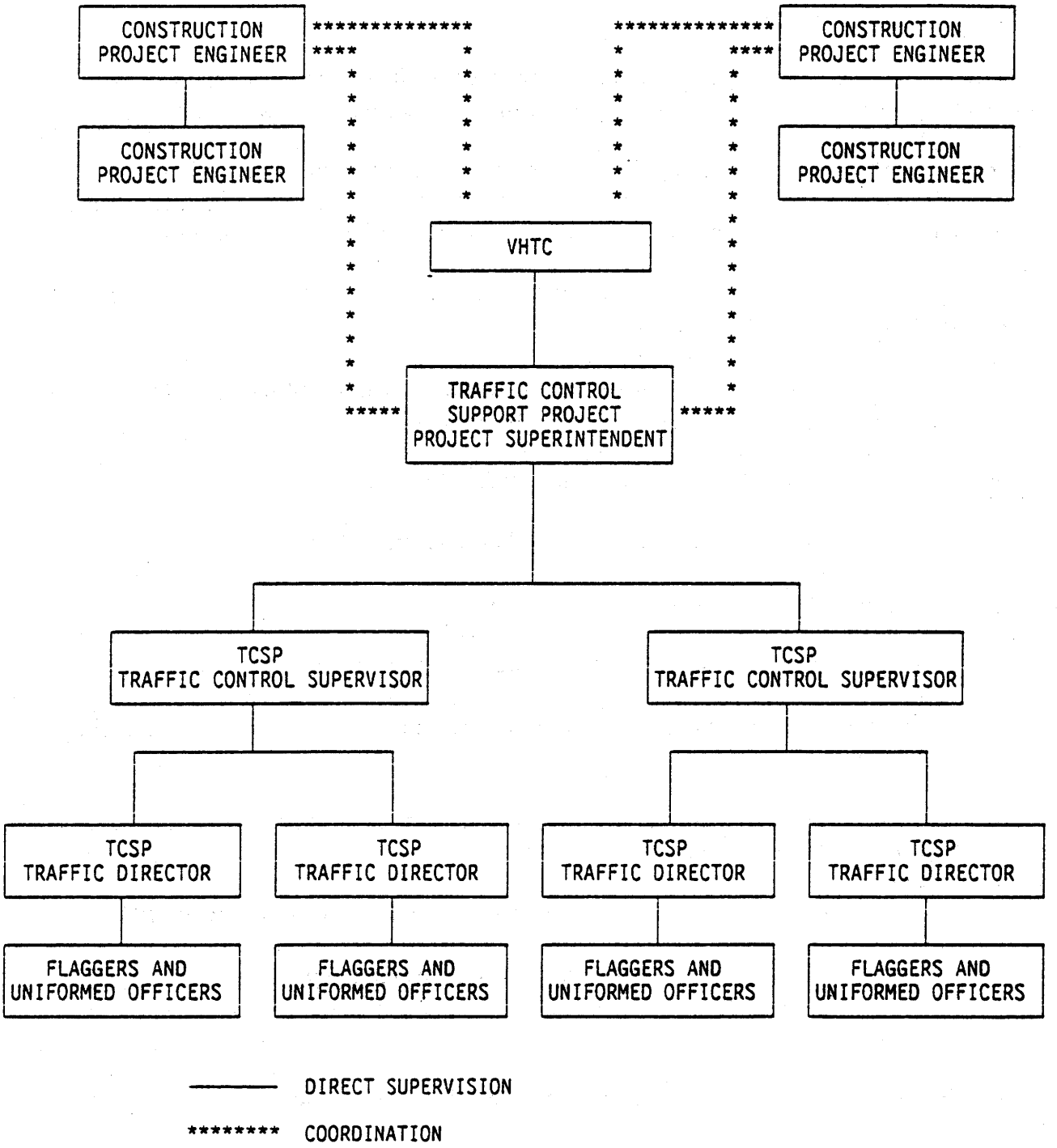


Figure 3 - I 25/I 70 Traffic Control Support Project Organizational Chart

an easy task and scheduled meetings are held as a minimum on a weekly basis, and sometimes more often. Any conflicts that do arise between the needs of the various construction contractors and other agencies are brought to the attention of the project engineer for resolution.

As I mentioned before, the contract provides all traffic control devices, traffic control supervision, and uniformed traffic control. Some specifics about these items are:

- Traffic control devices including furnishing, installing, moving, cleaning, maintaining, and removing construction signs, traffic cones, warning arrow panels, barricades, drum channelizing devices, and other traffic control devices.

- The traffic control supervisor's responsibilities are primarily supervision and coordination and include:

    * Maintain radio communication with project superintendent, as well as with the engineer and traffic control personnel.

    * Coordinate the activities of the traffic directors.

    * Attend weekly or daily coordination meetings.

    * Maintain and submit project diaries.

    * Provide supervision and immediate response to traffic control needs.

    * Maintain continuous inspection of the project for hazards to the traveling public.

- The traffic director's responsibilities are generally restricted to one operation, such as a detour or lane closure and include:

    * Coordinate the activities of flaggers and uniformed traffic personnel.

    * Maintain all traffic control devices, such as cleaning.

    * Provide flagger relief.

- The uniformed traffic control item has the following unique features about it:

    * The contractor is required to provide uniformed traffic control for the purpose of traffic control and enforcement throughout the project. The contractor uses mostly off-duty officers from Denver and Adams County because most of the projects are located within these entities.

* The contractor furnishes full-sized, late-model white sedans.

* The department furnishes hand-held radios with eight-channel capability and basic Denver Police channels one through five. The department also furnishes light bars for each vehicle.

PUBLIC RELATIONS PROJECT

The third and last item I want to cover is an effort we have been involved in now for about six months. It is a "Public Relations Project" dealing with construction in the same I 25/I 70 area.

A public relations consultant, Kinzley-Hughes, has been hired for a three-year period to help the department's public relations office and the district construction staff. The consultant will spearhead a campaign to educate and inform the public about upcoming construction activities in the corridor. The theme of this effort is titled, "The New I-25, Making Life Easier Down the Road."

The firm has created a cartoon character named "Dusty" the highway man. Dusty is a typical highway construction worker wearing a hard hat and vest. A recent article in the Rocky Mountain News stated, "Dusty will not be as pervasive as Bart Simpson, but he's sure to become ingrained in the minds of drivers while navigating Interstate 25 in the next three years."

Dusty's likeness has already appeared on highway construction information signs approaching the general work area. He is also featured in a brochure which was printed in both English and Spanish.

Dusty also has been the subject of other newspaper ads and articles and will be featured on an educational video. An animated talking version for radio and television public service announcements is being prepared. Other things the consultant will be involved in are community relations, coordination with enforcement and the news media, and setting up a speakers' bureau.

The total contract with Kinzley-Hughes is for $750,000. In addition to the various items discussed above it also includes preparation of a manual that will document everything done during the three-year campaign. The manual will be made available to other States and agencies.

One other item already in operation is a hot line. Drivers can get road construction and traffic information updates 24 hours a day by calling 573-ROAD. The information is updated twice daily to reflect changing construction schedules, detours, lane closures, etc.

One last item that is currently being worked on and should be completed sometime in February is a Highway Advisory Radio network. We are planning six locations for low-power radio stations that will broadcast on 530 AM. Signs will tell the driver when they are within range of one of the transmitters. Flashing lights will indicate that there is urgent information concerning traffic or construction. These signs will also include Dusty.

MANAGEMENT OF WORK ZONE TRAFFIC CONTROL – MAKING IT BETTER! SYNTHESIS OF PANEL DISCUSSION

The panel members, Harry B. Skinner, Federal Highway Administration; Bill Deyo, Florida Department of Transportation; Robert L. Morrison, Hancock County, Ohio; and Victor H. Liebe, American Traffic Safety Services Association, discussed management of work zone traffic control. Topics included: responsibilities of managers, safety, liability, training, and public information. The leadership role of FHWA, through new uniform standards, inspection, and training, was also addressed.

Harry B. Skinner, Federal Highway Administration, emphasized the significance of uniform standards, uniform application of standards, inspections, and training to insure that transportation systems support public safety. He stated the following major points:

- FHWA is convinced there is a need for a high level of uniform traffic control standards through work zones. The agency, therefore, is rewriting Part VI of the MUTCD, which deals with work zones. Rulemaking is expected to be completed sometime in 1992.

- FHWA plans to publish Part VI as a stand-alone document once the standards are adopted so that people involved in construction and design of work zone plans will have the information before the new manual is released in 4 to 5 years.

- Uniform standards must be accompanied by uniform application.

- Quality control is important. Too frequently devices are not used properly. Some are dirty; others are used in the wrong place. The right device in the right place at the right time is the only way to provide service to motorists that we should be providing.

- Inspection of work zones is crucial. Reducing the time inspectors spend inspecting traffic control in work zones is not wise. Some think that relegating the responsibility of work zone safety to the contractor would mitigate some liability that the State would have in work zones, but it is virtually impossible to absolve jurisdictions for responsibility for control of traffic or accidents.

- Good intentions regarding safety in work zones must be translated into action as new items and methods come on the market.

- I recommend developing "The Road to Safer Work Zones" as an in-house program similar to the successful "Road to Better Pavement Markings." A one-week or short-week program in each State would include process review, a look at standards and methods, as well as training.

Bill Deyo, Florida Department of Transportation, examined the importance of training and up-to-date uniform standards. He made these points:

- Adequate standards exist, and they are constantly being upgraded and changed to meet the changes in traffic patterns or users, including elderly drivers. A lack of training is the primary culprit in not getting proper orientation of devices in the work zone. A lack of training has led to misunderstanding on proper placement, the meaning of certain signs, and the proper way to have tapers or transitions from multilane to two-lane.

- By statute, Florida has pledged to train all involved in work zones by August 1991. Anyone who has anything to do with design, construction, implementation of plans, and preparation of plans involving traffic control will have to attend a DOT work zone traffic control course. Work zone supervisors will be certified through the ATSSA training course; DOT engineers will provide training to DOT people responsible for work zone set-up and design and in-house consultants. Each person must be tested according to the level to be certified.

- We can't overemphasize the importance of training. Even veteran designers with 35 years experience have learned something from the training. More than 1,000 total will be trained in a year. Through training sessions, we will achieve a higher degree of proficiency in all areas.

- The Florida "Green Book," which is based on the AASHTO Policy on Geometric Design of Highways and Streets, gets information to municipalities, counties, and smaller cities. The Green Book applies uniform minimum standards for design, construction, and maintenance of public roads.

- By statute, an advisory committee for the Florida Green Book is made up of representatives from seven State DOT districts and the Florida Turnpike, including design engineers, county administrators, city engineers, and contractors. The committee meets annually to update changes in MUTCD, Florida standards, and AASHTO and sets the stage for municipalities and counties to comply with Florida standards. Emphasis is put on work zone traffic control. A chapter on traffic engineering and work zones is being added.

- In 1988 the legislature gave DOT the right to require certification of utility companies for work zone traffic control. Most were already complying, but the State offers training that utility companies can attend.

- Florida has a statewide utility user group comprised of DOT and the utility representatives. The user group has agreed to abide by Florida standards for work zone traffic control. Some have their own training sessions to certify their road crews for proper procedures in emergencies, as well as on planned work sites for relocation or adjustment of utilities.

- In Florida private developers are required to comply with Florida standards for signing within their bounds. Implementation of uniform minimum standards within private developments, however, will be difficult.

- Most States publicize work zone safety primarily in the summer. In Florida, however, construction takes place year-round. The fact that we are a year-round construction State with many tourists makes it doubly important to have work zone traffic control plans emphasized in design, construction, and project management.

Robert L. Morrison, Hancock County, Ohio, stressed the value of communication in management. He made the following points:

- At the local government level, information doesn't seem to flow as well as should. Somewhere between Federal and local, information gets set aside.

- Education for the highway worker is a must. Localities often don't have large staffs and money; education is the main tool.

- The RTAP program and the T^2 Centers are doing a good job getting the information to the local level.

- His jurisdiction educates the public through the news media.

- Another conduit of public information is CB radios, which motorists can scan for information on work zones.

- CB radios are also helpful in obtaining motorists' reactions to work zones. Sit near a work zone, not visible, and turn on your CB radio to hear motorists' comments. People will talk freely.

- A snow plow is a moving work zone. We haven't done as good a job as we could in educating the public or our operators on how they should conduct themselves to insure safe operations of snow plows. Problems include illumination and backing up.

- Motorists of all abilities are the concern of those responsible for work zones. It's important to remember that we have an obligation--we're responsible for that person, sober, intoxicated, or with impairments.

Victor H. Liebe, American Traffic Safety Services Association, emphasized teamwork. His key points were as follows:

- The management of work zone traffic control requires teamwork, regardless of the operation.

- Management begins at the top of the agency. Upper level management needs training. Managers expect the workers doing the labor to respond to safety procedures, but upper level management often does not set an example.

- The responsibilities of project managers include: command and control of every aspect of the work zone situation; communication among their troops, prime contractors and subcontractors; and supervision.

- The planning agency is responsible for design, procedure, specifications, contracts, and overall control.

- Hire good personnel and provide good training, starting at the upper level.

- Promote more cooperative efforts in all elements involved in the project. Teamwork promotes efficiency; efficiency promotes safer situations; and safer situations reduce tort liability consequences.

- Let each entity do what they do best. Let the contractor do his job; let the subcontractor, if trained, handle traffic control, but there must be cooperative effort.

- Don't be afraid to try new, innovative things. The Federal Aid Program Manual 642-12 says there should be provisions for using a contractor's plan, if approved by the agency. The intent is "Use the most efficient plan."

- You can't always do everything experts recommend because of timing, terrain, funding. Upper level managers are responsible for controlling the risk.

- A significant function of the project manager is to insure that work zone safety is at its best. The upper level of the agency must be sure responsibility goes all the way down.

APPENDIX A

WORK ZONE TRAFFIC CONTROL SYMPOSIUM

MAKING IT WORK

SYMPOSIUM PROGRAM

Sheraton World Hotel
Orlando, Florida

Friday, January 18, 1991

7:30 - 8:30 AM

REGISTRATION - MAIN LOBBY

CONTINENTAL BREAKFAST - ARCTIC AND ATLANTIC BALLROOMS

8:30 AM

GENERAL SESSION - ARCTIC AND ATLANTIC BALLROOMS

Moderator - Harry B. Skinner, Federal Highway Administration, Washington, D.C.

Welcome and Opening Remarks - William Deyo, Florida Department of Transportation, Tallahassee, Florida

8:45 AM

Work Zone Safety - Is It Working? - E. Dean Carlson, Federal Highway Administration, Washington, D.C.

9:15 AM

New Part VI-MUTCD - Philip O. Russell, Federal Highway Administration, Washington, D.C.

9:45 AM

Causes and Prevention of Tort Liability in Work Zones - Russell M. Lewis, Consultant, Annandale, Virginia

10:15 AM

BREAK

10:30 AM

Moderator - Philip O. Russell, Federal Highway Administration, Washington, D.C.

Contracting Procedures for Work Zones - Panel Discussion

Larry C. Smith, Federal Lands Highway Office, Washington, D.C.
Thomas Hicks, Maryland State Highway Administration, Hanover, Maryland
Richard A. Dun, Hubbard Construction Co., Orlando, Florida
I. Sharon Fischer, Priceless Sales and Services, Inc., Baltimore, Maryland

12:00 PM

LUNCH - CORAL ROOMS A AND B

1:30 PM

Moderator - Harry B. Skinner, Federal Highway Administration, Washington, D.C.

The Use of Police for Work Zone Traffic Control - Captain Terry W. Conner, Arizona Department of Public Safety, Phoenix, Arizona

2:00 PM

New Concepts in Work Zone Traffic Control - Robert M. Garrett, American Traffic Safety Services Association, Fredericksburg, Virginia

2:30 PM

Warrants and Proper Deployment of Flashing Arrow Panels - Joseph J. Lasek, Federal Highway Administration, Washington, D.C.

3:00 PM

BREAK

3:15 PM

Moderator - Philip O. Russell, Federal Highway Administration, Washington, D.C.

Current Practices in the Use of Steady Burn Warning Lights - Gerhart F. King, KLD Associates, Inc., Huntington Station, New York

3:45 PM

Guidelines for the Use of Truck-Mounted Attenuators - Jack B. Humphreys, University of Tennessee, Knoxville, Tennessee

4:15 PM

Safe Deployment of Traffic Control Devices - Jerry Hietpas, Action Safety Supply Co., Oklahoma City, Oklahoma

4:45 PM

ADJOURN

5:15 PM

RECEPTION FOR ATTENDEES AND GUESTS - PATIO

Saturday, January 19, 1991

7:30 - 8:30 AM

REGISTRATION - MAIN LOBBY

CONTINENTAL BREAKFAST - BREAK-OUT SESSION ROOMS

8:30 AM

BREAK-OUT SESSIONS

(Three concurrent break-out sessions with presentations and discussions focused on making it work for work zones on freeways, city and suburban streets, and rural roads. In addition to assigned speakers, attendees are encouraged to present their own experiences and procedures.)

GROUP 1 - TRAFFIC CONTROL FOR WORK ZONES ON FREEWAYS-INDIAN BALLROOM

Moderator - Philip O. Russell, Federal Highway Administration, Washington, D.C.

Planning and Scheduling Freeway Lane Closures - Raymond A. Krammes, Texas A & M University, College Station, Texas

Real Time Traffic Control and Changeable Message Signs - Thomas Hicks, Maryland State Highway Administration, Hanover, Maryland

Speed Control Procedures - James Migletz, Graham-Migletz Enterprises, Independence, Missouri

The I-95 (FL) Expansion Program Work Zone Traffic Control - William R. Walsh, Florida Department of Transportation, Ft. Lauderdale, Florida

GROUP 2 - TRAFFIC CONTROL FOR WORK ZONES ON CITY AND SUBURBAN STREETS - PACIFIC BALLROOM

Moderator - Joseph J. Lasek, Federal Highway Administration, Washington, D.C.

Work Zone Traffic Control for Urban/Suburban Streets -- Overview - Archie C. Burnham, Jr., Consultant, Ellenwood, Georgia

Protecting Pedestrians in Work Zones: Role for the MUTCD - Errol C. Noel, Howard University, Washington, D.C.

From No Cones to No Accidents - Rick L. Maddux, Cedar Falls Utilities, Cedar Falls, Iowa

City of Overland Park, Kansas, Work Zone Traffic Control Procedures - Larry W. Settle, City of Overland Park, Overland Park, Kansas

GROUP 3 - TRAFFIC CONTROL FOR WORK ZONES FOR RURAL ROADS - MEDITERRANEAN ROOMS A AND B

Moderator - Harry B. Skinner, Federal Highway Administration, Washington, D.C.

Lane Closure Techniques for Two-Lane Roads - Jon V. Jackels, Minnesota Department of Transportation, St. Paul, Minnesota

Traffic Control for Work Zones for Rural Roads - Applying the MUTCD to Rural Roads - Larry C. Smith, Federal Lands Highway Office, Washington, D.C.

Traffic Control for Low Volume Roads - Robert L. Morrison, Hancock County, Findlay, Ohio

Work Zone Traffic Control Training Through Regional Transportation Assistance Program (RTAP) - Henry Sandhusen, Federal Highway Administration, Washington, D.C.

10:15 - 10:30 AM

BREAK

10:30 AM

Break Out Sessions Continue

12:00 PM

LUNCH - CORAL ROOMS A AND B

1:00 PM

GENERAL SESSION - INDIAN AND PACIFIC BALLROOMS

Moderator - Joseph J. Lasek, Federal Highway Administration, Washington, D.C.

Public Awareness of Work Zone Activity - Lynda J. South, Virginia Department of Transportation, Richmond, Virginia

1:30 PM

Inspection of Work Zone Traffic Control Hardware - A Systematic Approach - Donald L. Woods, Texas A & M University, College Station, Texas

2:00 PM

Worksite Traffic Control Training and Certification - Victor H. Liebe, American Traffic Safety Services Association, Fredericksburg, Virginia

2:30 PM

BREAK

2:45 PM

Moderator - Philip O. Russell, Federal Highway Administration, Washington, D.C.

Management of Work Zone Traffic Control - Making It Work! - Johan J. Bemelen, Colorado Department of Highways, Denver, Colorado

3:15 PM

Management of Work Zone Traffic Control - Making It Better! - Panel Discussion

Harry B. Skinner, Federal Highway Administration, Washington, D.C.
William Deyo, Florida Department of Transportation, Tallahassee, Florida
Robert L. Morrison, Hancock County, Findlay, Ohio
Victor H. Liebe, American Traffic Safety Services Association, Fredericksburg, Virginia

4:15 PM

CLOSING REMARKS AND ADJOURN - Philip O. Russell, Federal Highway Administration, Washington, D.C.

APPENDIX B

Attendees

The following is a listing of those who attended--including the speakers--the Symposium on Work Zone Traffic Control.

Dr. Joseph A. Abal
President
Abal and Associates
1403 Levy Avenue
Tallahassee, FL 32310
(904) 575-6759

Mr. Robert W. Attaway
Assistant Director
UNC Institute for Transportation R & E
P.O. 17489
Raleigh, NC 27619
(919) 878-8080

Mr. Jim Barnack
Civil Engineer-III (Traffic)
NYSDOT
Building 5, Room 314
Albany, NY 12303
(518) 457-3537

Mr. Julian R. Beaver
President
Southeast Collision Analysis
101 Water Street
Brunswick, GA 31520
(912) 267-6900

Mr. R. Clark Bennett
Director, Office of Highway Safety
Federal Highway Administration
400 7th Street, S.W., HHS-1
Washington, DC 20590
(202) 366-1153

Ms. Carol L. Bloom
President
ADIAN Engineering Corporation
900 Orchard Way
Silver Spring, MD 20904
(301) 384-2928

Mr. Roy W. Anderson
President
TranSafety, Inc.
5811 Oak Leather Drive
Burke, VA 22015
(703) 239-2122

Mr. David A. Badger
Civil Engineer
Forest Service USDA
P.O. Box 96090
Washington, DC 20090
(202) 453-9424

Mr. Tim Baughman
Work Zone Traffic Control Engineer
South Carolina DHPT
P.O. Box 191
Columbia, SC 29202
(803) 737-1455

Mr. Johan J. Bemelen
Staff Traffic Engineer
Colorado Department of Highways
4201 E. Arkansas Avenue
Denver, CO 80222
(303) 757-9271

Mr. Steven Blakley
Zook, Moore and Associates
901 Northpoint Parkway #200
West Palm Beach, FL 33407
(407) 683-4017

Mr. Jeffrey A. Bloom
Vice President
ADIAN Engineering Corporation
900 Orchard Way
Silver Spring, MD 20904
(301) 384-2928

Mr. Thomas P. Boyce
Product Manager
Stimsonite Corporation
7542 N. Natches
Niles, IL 60648
(708) 647-7717

Mr. James A. Bragdon
President
Bradgon & Associates, Inc.
P.O. Box 1292
Grand Junction, CO 81502
(303) 241-2140

Mr. Joseph H. Broom
Traffic Control Work Zone Engineer
Alabama Highway Department
Rt. 2, Box 152-M
Eclectic, AL 36024
(205) 262-6127

Ms. Kathleen M. Buck Holst
President
Alternative Construction Controls, Inc.
57 W. New Avenue
Lemont, IL 60439
(708) 257-8383

Mr. Archie C. Burnham
Consultant Engineer
Consultant
5829 Little Mountain Drive
Ellenwood, GA 30049
(404) 987-0490

Mr. E. Dean Carlson
Executive Director
Federal Highway Administration
400 7th Street, S.W., HOA-3
Washington,, DC 20590
(202) 366-2242

Mr. James Catalino
Chief Bridge Engineer
Dyer, Riddle, Mills and Precourt
1501 East Colonial Drive
Orlando, FL 32809
(407) 896-0594

Mr. Charles S. Boyd
Field Operations Engineer
Federal Highway Administration
Federal Building, Room 3128
Little Rock, AR 72201
(501) 378-5309

Mr. Bill Bremmer
Safety and Traffic Operations Engineer
Federal Highway Administration
4502 Vernon Boulevard
Madison, WS 53705
(608) 264-5942

Mr. John Brousseau
Traffic Consultant
Office of Traffic Consulting
44 Madras Place
Brampton, Ontario, Canada L652Z2
(416) 793-1302

Mr. James Buckson
Highway Engineer
Federal Highway Administration
200 N. High Street, Room 328
Columbus, OH 43215
(614) 469-6874

Mr. Carlos A. Caceres
DOTD Staff Engineer Supervisor
Louisiana DOTD
P.O. Box 94245, Captial Station,Sect. 21
Baton Rouge, LA 70804
(504) 358-9109

Mr. Robert Case
Senior Engineer
Collier County Transportation Services
3301 E. Tamiami Trail, Building D
Naples, FL 33964
(813) 774-8487

Mr. Neal A. Chambers
Manager/Traffic Operations Branch
Oklahoma Dept. of Transportation
200 N.E. 21st Street
Oklahoma, OK 73105
(405) 521-2861

Lt. Ronnie Chapman
Lake Charles Police Department
P.O. Box 1564
Lake Charles, LA 70602
(318) 491-1311 Ext. 336

Capt. Terry W. Conner
Special Services Division Commandor
Arizona Department of Public Safety
2102 W. Encanto Blvd.
Phoenix, AZ 85005
(602) 223-2044

Mr. Cooper Curtis
Assistant Manager
Orange County Public Works
4200 Whitcomb Avenue
Orlando, FL 32809
(407) 836-7930

Ms. Janet Degner
Manager
Florida T-Square Center
512 Weil Hall, University of Florida
Gainesville, FL 32611
(904) 392-0378

Mr. Bill Deyo
Director of Design
Florida Department of Transportation
605 Suwanee Street
Tallahassee, FL 32301
(904) 488-5596

Mr. Richard A. Dun
Director of Contract Administration
Hubbard Construction Company
P.O. Box 54-7217
Orlando, FL 32854
(407) 645-5500

Mr. Rodney Edwards
Head, Traffic Signing Section
Ministry of Transporatation
1201 Wilson Avenue,
Rm.236, Central Bldg.
Downsview, Ontario, Canada M3M1J8
(416) 235-3800

Mr. Edward Cole
Market Development Sr. Administrator
3M Company
3M Center, Building 223-3N-01
St. Paul, MN 55144
(612) 736-5207

Mr. Dave Cowan
Vice President/General Manager
Plastic Safety Systems
P.O. Box 20140
Cleveland, OH 44120
(216) 231-8590

Mr. Donald Dahlinger
Civil Engineering Manager I
Tennessee Department of Transportation
505 Deaderick Street, Suite 1000
Nashville, TN 37243
(615) 741-3033

Mr. Dean A. Derks
Construction Signing Engineer
Michigan Department of Transportation
T & S Division, P.O. Box 30050
Lansing, MI 48909
(517) 335-2853

Mr. Frank D. Dobiszewski
County Traffic Engineer
County of Union
P.O. Box 2607
Westfield, NJ 07091
(908) 789-3672

Mr. George D. Ebersole
President
Energy Absorption Systems, Inc.
1 East Wacker Drive, #3000
Chicago, IL 60601
(312) 467-6750

Mr. Chung Eng
Highway Engineer
Federal Highway Administration
400 7th Street, S.W., HNG-21
Washington, DC 20590
(202) 366-1555

Mr. Scott England
Supervisor
Highway Traffic Control
P.O. Box 269
Thornville, OH 43076
(614) 246-4878

Mr. Tom Ervin
Secretary-Treasurer
Work Zone Inc.
P.O. Box 1630
Harvey, LA 70059
(504) 366-7788

Ms. Betty Evans
Executive Director
Dade County Safety Council
8491 NW 17th Street, Suite 100
Miami, FL 33126
(305) 592-3232 Ext. 105

Ms. Vicky Forando
Safety Program Engineer
Federal Highway Administration
Leo O'Brien Building, 9th Floor
Albany, NY 12209
(518) 472-7517

Mr. Robert M. Garrett
Executive Director
ATSSA
5440 Jefferson Davis Highway
Fredericksburg, VA 22401
(703) 898-5400

Ms. Nancy Geisler
Engineer
Bellomo-McGee, Inc.
8330 Boone Blvd.
Vienna, VA 22182
(703) 847-3071

Mr. Mike Gostovich
Staff Engineer, Operations
Wyoming State Highway Department
P.O. Box 1708
Cheyenne, WY 82002
(307) 777-4492

Mr. Charles Ensor
Senior Engineer Inspector
Orange County Public Works
4200 Whitcomb Avenue
Orlando, FL 32809
(407) 836-7930

Mr. Jim Etherton
Director of Highways
R S & H, Inc.
P.O. Box 4850
Jacksonville, FL 32201
(904) 296-2000

Ms. I. Sharon Fischer
President, American Subcontractors Assoc.
Priceless Sales and Service
8120 Norris Lane
Baltimore, MD 21222
(301) 285-1900

Mr. Jessie Fullingim
Traffic Engineer, Div. 3
Oklahoma Department of Transportation
P.O. Box 549
Ada, OK 74820
(405) 332-1526

Mr. John Gaynor
Senior Traffic Engineer
Texas State Department of Highways
P.O. Box 1386
Houston, TX 77251
(713) 869-4571 Ext. 401

Mr. George M. Gilhooley
District Traffic Operations Engineer
Florida Department of Transportation
719 S. Woodland Boulevard
DeLand, FL 32720
(904) 736-5212

Mr. Jerry L. Graham
President
Graham-Migletz Enterprises, Inc.
P.O. Box 348
Independence, MO 64050
(816) 254-1788

Mr. Richard O. Gumtau
Highway Safety Programs Engineer
Federal Highway Administration
P.O. Box 902003
Fort Worth, TX 76102
(817) 334-3926

Mr. Donald C. Harris
Research Analyst
3M Company
3M Center Building 582-01-15
St. Paul, MN 55144
(612) 736-0844

Ms. Martha Heine
Associate Editor
Roads and Bridges Magazine
380 Northwest Highway
Des Plaines, IL 60016
(708) 298-6622

Mr. John O. Hibbs
Instructor
University of Maryland T-Sq. Center
5113 Bradfield Court
Annandale, VA 22003
(703) 764-2694

Mr. Jerry Hietpas
President
Action Safety Supply
Box 270238
Oklahoma City, OK 73127
(405) 787-2244

Mr. Vince Howard
Sr. Designer
RS & H, Inc.
P.O. Box 4850
Jacksonville, FL 32201
(904) 296-2000

Mr. Jack B. Humphreys
Professor
University of Tennessee
112 Perkins Hall
Knoxville, TN 37996
(615) 974-7707

Mr. Dennis Hagan
Perry County Engineer
Perry County
P.O. Box 29
New Lexington, OH 43076
(614) 342-2191

Mr. Peter J. Hatzi
Highway Engineer
Federal Highway Administration
Turner-Fairbank Research Center, HRT-20
McLean, VA 22101
(703) 285-2517

Ms. Barbara J. Heintz
Manager
Alternative Construction Controls, Inc.
57 W. New Avenue
Lemont, IL 60439
(708) 257-8383

Mr. Tom Hicks
Chief Traffic Engineer
Maryland State Highway Administration
7491 Connelley Drive
Hanover, MD 21076
(301) 781-5815

Mr. H. R. Hofener
Chief Traffic Engineer
Oklahoma Department of Transportation
200 N.E. 21st Street
Oklahoma City, OK 73105
(405) 521-2861

Mr. Fred J. Hughes
Safety Supervisor
Florida Power and Light Company
P.O. Drawer D
West Palm Beach, FL 33402
(407) 684-7611

Mr. Peter Ing
Research Engineer
Alberta Transportation
4999 98 Avenue
Edmonton, Alberta, Canda T6L6J5
(403) 422-2750

Mr. Victor Iulo
Principal Traffic Safety Investigator
Somerset County Engineers Office
P.O. Box 3000
Somerville, NJ 08876
(201) 231-7024

Mr. John B. Jackson
Vice President
E.L. Hilts and Co.
P.O. Box 1789
Hickory, NC 28603
(704) 328-8141

Mr. Reed K. Jarvi
Professional Engineer
Agnoli, Barber and Brundage, Inc.
7400 Tamiami Trail North
Naples, FL 33963
(813) 597-3111

Mr. David Jones
Marketing Development Supervisor
3M Company
3M Center, Building 223-3N-01
St. Paul, MN 55101
(612) 733-5136

Mr. Lester Jones
Traffic Operations Engineer
Florida Department of Transportation
605 Suwannee Street, M.S. 36
Tallahassee, FL 32301
(904) 488-8798

Mr. Olin L. Kelly
Principal Engineer
Kelly Engineering
P.O. Box 715
Tahlequah, OK 74465
(918) 457-5848

Mr. Marc Knapp
District Const. Service Engineer
Florida Department of Transportation
1300 N. Westshore
Tampa, FL 33610
(813) 871-7390

Mr. Jon Jackels
Work Zone Safety Coordinator
Minnesota Department of Transportation
Transportation Building, Room G4
St. Paul, MN 55155
(612) 296-2721

Mr. Lawrence E. Jackson
Higway Engineer
National Transportation Safety Board
800 Independence Avenue, S.W.
Washington, DC 20590
(202) 382-6620

Mr. Brook M. Jerzyk
Market Manager
Reflexite Corporation
315 South Street
New Britain, CT 06050
(203) 223-9297

Cpl. Jim Jones
Lake Charles Police Department
P.O. Box 1564
Lake Charles, LA 70602
(318) 491-1311 Ext. 326

Mr. James R. Keaton
Marketing Manager
3M Company
TCM Division - Building 223-3N-01
St. Paul, MN 55144
(612) 736-5994

Mr. Gerhart F. King
Mgr. Transp. & Safety Engineering Proj.
KLD Associates, Inc.
300 Broadway
Huntington Station, NY 11746
(516) 549-9803

Ms. Claudia Knesek
Director/Ed. Coordinator
Rutgers University
Building 4161, Kilmer Campus
New Brunswick, NJ 08903
(201) 932-5074

Mr. Ken F. Kobetsky
Director Traffic Engineer Division
West Virginia Dept. of Transportation
Capital Complex
Charleston, WV 25305
(304) 348-3722

Mr. Steven L. Koser
RTAP Safety Engineer
Pennsylvania State University
Room 68, Crags Building
Middletown, PA 17507
(717) 948-6420

Mr. Raymond A. Krammes
Asst. Professor of Civil Engineering
Texas A & M University
Texas Transportation Institute
College Station, TX 77843
(409) 845-9898

Mr. Lall G. Kwatra
Supervising Traffic Engineer
Port Authority of NY-NJ
78 Van Blarcom Lane
Wyckoff, NJ 07481
(201) 216-2436

Mr. Joseph Lasek
Chief, Technical Development Branch
Federal Highway Administration
400 7th Street, S.W., HHS-11
Washington, DC 20590
(202) 366-2174

Mr. Robert A. Lavette
District Director - Operations
Florida Department of Transportation
719 S. Woodland Boulevard
DeLand, FL 32720
(904) 736-5029

Dr. Russell M. Lewis
Consultant
8313 Epinard Court
Annandale, VA 22003
(703) 323-9694

Mr. David L. Koch
Transportation Specialist III
Oklahoma Department of Transportation
200 N.E. 21st Street
Oklahoma City, OK 73105
(405) 521-2861

Mr. Andrew Kramer
President
National Capital Industries
P.O. Box 287
Bladensburg, MD 20710
(301) 864-4150

Mr. Joseph Kunkel
Engineer III
Orange County Public Works
4200 Whitcomb Avenue
Orlando, FL 32809
(407) 836-7930

Mr. Andrew J. Lampe
Government Relations Manager
3M Company
1101 15th Street, N.W.
Washington, DC 20005
(202) 331-6952

Dr. Steve Lawson
Senior Research Officer
Birmingham City
1 Lancaster Circus
Birmingham, UK B47D1
+4421-300-7429

Mr. Elmer J. Leland
Regional Traffic Oper/Safety Engineer
Federal Highway Adminsitration
222 S.W. Columbia, Suite 600
Portland, OR 97201
(503) 326-2071

Mr. Victor H. Liebe
Director of Education
ATSSA
5440 Jefferson Davis Highway
Fredericksburg, VA 22407
(703) 898-5400

Mr. Bill Linkovich
District Safety Engineer
Florida Department of Transportation
719 S. Woodland Blvd
DeLan, FL 32720
(904) 736-5228

Mr. Ralph Lundregan
Sales Development Executive
Avery
P.O. Box 680
Middletown, MD 21769
(800) 327-4461

Mr. Rick L. Maddux
Safety and Training Coordinator
Cedar Falls Utilities
612 E. 12th St., P.O. Box 769
Cedar Falls, IA 50613
(319) 266-1761 Ext. 367

Mr. Ron Martindale
Engineering Assistant III
Alaska Department of Transportation
P.O. Box 196900
Anchorage, AK 99519
(907) 266-1593

Mr. Edward G. McClane
Engineering Technician II
Palm Beach County
160 Australian Drive
West Palm Beach, FL 33409
(407) 684-4030

Mr. David McKee
Safety Officer
Safe-T-Flare Rental Service, Inc.
P.O. Box 10648
Kansas City, MO 64118
(816) 436-2548

Mr. James Migletz
Vice President
Graham-Migletz Enterprises
P.O. Box 348
Independence, MO 64050
(816) 254-1788

Mr. William R. Lowery
Sr. Project Manager
Transportation Consulting Group
1201 S. Orlando Avenue
Winter Park, FL 32790
(407) 628-0875

Mr. Bud MacFarlane
Product Manager
Plastic Safety Systems, Inc.
P.O. Box 20140
Cleveland, OH 44120
(216) 231-8590

Mr. John A. Malecki
Supervisor, Traffic Safety Operations
Somerset County Engineers Office
P.O. Box 3000
Somerville, NJ 08876
(201) 231-7024

Mr. John McCarthy
Sr. Engineer/Traffic
New Jersey Department of Transportation
P.O. Box 26
Cape May Court House, NJ 08210
(609) 886-4249

Dr. Hugh W. McGee
Principal
Bellomo-McGee, Inc.
8330 Boone Blvd., Suite 700
Vienna, VA 22182
(703) 847-3071

Mr. John C. Merritt
Assistant Traffic Engineer
City of Colorado Springs
30 S. Nevada, Suite 404
Colorado Springs, CO 80903
(719) 578-6663

Mr. Robert L. Morrison
Hancock County Engineer
Hancock County
1900 Lima Avenue
Findlay, OH 45840
(419) 422-7433

Mr. Frank Myers
Managing Director
APH Road Safety, LTD.
Unit 7, Dunlop Road,
Hunt End, Redditch, UK B975XP
(0) 52-740-1401

Mr. Charles Newton
Traffic Maintenance Engineer
Florida Department of Transportation
1000 N.W. 111 Avenue
Miami, FL 33172
(305) 470-5335

Ms. Sofia Nirshberg
President
VN Engineers, Inc.
74 Forbes Avenue
New Haven, CT 06512
(203) 469-8077

Mr. Raymond F. Novak
Regional Construction Engineer
New York State Dept. of Transportation
333 E. Washington Street
Syracuse, NY 13202
(315) 428-4406

Mr. Kurt Obendorfer
Engineer
Summit County
538 E. South Street
Akron, OH 44311
(216) 379-2850

Mr. Bobby J. Parker
Assistant Construction Engineer
Arkansas State Highway & Transportation
P.O. Box 2261
Little Rock, AR 72203
(501) 569-2251

Ms. Jane K. Pemble
Traffic Engineer
Anoka County Highway Department
1440 Bunker Lake Blvd.
Andover, MN 55304
(612) 754-3520

Ms. Julie Neebel
Traffic Control Engineer
Wisconsin Department of Transportation
Room 601, P.O. Box 7916
Madison, WI 53707
(608) 266-8417

Mr. Jeffrey Nicholson
Executive Vice President
ADDCO
69 Empire Drive
St. Paul, MN 55103
(612) 224-8800

Dr. Errol Noel
Professor
Howard University
Department of Civil Engineering
Washington, DC 20059
(202) 806-6668

Mr. Bruce T. Nyquist
Traffic Investigations Engineer
Vermont Agency of Transportation
133 State Street
Montpelier, VT 05602
(802) 828-2181

Mr. Ron Owenby
Sales and Marketing Manager
Winko-Matic/Multisonic
6301 Best Friend Road
Norcross, GA 30071
(404) 552-5400

Mr. Dennis A. Payne
Consultant
Accident Cause Analysis
8321 Terrace Wood Circle
Tampa, FL 33615
(813) 884-5558

Mr. Steve Pemble
Senior Technician
Barton-Aschman Associates, Inc.
111 Third Avenue South, Suite 350
Minneapolis, MN 55401
(612) 332-0421

Mr. Frank J. Petrik, P.E.
Director, Division of Engineering
County of Union
P.O. Box 2607
Westfield, NJ 07091
(908) 789-3672

Mr. Eric Pfeifer
Project Engineer
Dyer, Riddle, Mills & Precourt
1505 E. Colonial Drive
Orlando, FL 32803
(407) 896-0594

Mr. Herb Pooler
Barricade Supervisor
City of Colorado Springs
P.O. Box 1575-1370
Colorado Springs, CO 80901
(719) 578-6785

Mr. George E. Rice
Transportation Safety Engineer
Federal Highway Administration
227 N. Bronough Street, Room 2015
Tallahassee, FL 32301
(904) 681-7495

Mr. J. K. Robinson
Manager,Traffic Mgmt. & Eng. Office
Ministry of Transportation
1201 Wilson Ave., Room 236,Centrl Bldg.
Downsview, Ontario, Canada M3M1J8,
(416) 235-3785

Mr. Tom Russell
Director, Office of Engineering
Federal Highway Administration
1720 Peachtree Road, Suite 200
Atlanta, GA 30367
(404) 347-4075

Ms. Beverly G. Seamon
President
Work Zone Inc.
P.O. Box 1630
Harvey, LA 70059
(504) 366-7788

Mr. Mike Pettis
President
Advanced Warning, Inc.
P.O. Box 1911
Muskogee, OK 74402
(918) 682-0039

Mr. Morris Phinney
Horizon Signal
202 Conestoga Road
Wayne, PA 19087
(800) 852-8796

Mr. William J. Raves,Jr.
Traffic Control Specialist Supervisor
Pennsylvania Turnpike Commission
P.O. Box 8531
Harrisburg, PA 17105
(717) 939-9551 Ext. 3740

Mr. David Richert
Operations Manager
Lafrentz Road Services, Ltd.
8225 Coronet Road,
Edmonton, Alberta, Canada T6E4N7
(403) 465-7586

Mr. Philip O. Russell
Chief, Traffic Control Device Branch
Federal Highway Administration
400 7th Street, S. W. HHS-31
Washington, DC 20590
(202) 366-2184

Mr. Henry Sandhusen
Highway Engineer
Federal Highway Administration
400 7th Street, S.W., HHS-11
Washington, DC 20590
(202) 366-2170

Mr. Murry D. Segal
Transportation Consultant
P.O. Box 517
Rye, NH 03870
(603) 433-4390

Mr. Larry W. Settle
Sr. Traffic Engineer Technician
City of Overland Park
8500 Santa Fe Drive
Overland Park, KS 66212
(913) 381-5252 Ext. 325

Mr. Larry C. Smith
Chief, Engineering & Operations Division
Federal Highway Administration
400 7th Street, S.W., HFL-20
Washington, DC 20590
(202) 366-9478

Mr. Peter Spear
Sales Manager
Davidson Plastics Company
18726 E. Valley Highway
Kent, WA 98032
(206) 251-8140

Mr. Jesse Story
Chief, Program Management Branch
Federal Highway Administration
400 7th Street, S.W., HNG-21
Washington, DC 20590
(202) 366-1555

Mr. Tony Sullivan
Staff Traffic Engineer
Arkansas State Highway & Transportation
P.O. Box 2261
Little Rock, AK 72203
(501) 569-2232

Dr. John E. Tidwell
Assistant Director
University of Tennessee, Transp. Center
South Stadium Hall
Knoxsville, TN 37996
(615) 974-5255

Mr. Robert B. Toomey
President
L & C Flashing Barricades, Inc.
P.O. Box 251
Canton, MA 02021
(617) 828-3481

Mr. Harry Skinner
Chief, Traffic Control Division
Federal Highway Administration
400 7th Street, S.W., HHS-30
Washington, DC 20590
(202) 366-2185

Ms. Lynda South
Director, Office of Public Affairs
Virginia Department of Transportation
1401 East Broad Street
Richmond, VA 23219
(804) 786-2715

Mr. Daniel Sprengeler
Assistant Methods Engineer
Iowa Department of Transportation
800 Lincoln Way
Ames, IA 50010
(515) 239-1402

Mr. John E. Story
Vice President
Warning Lites of Minnesota
4700 Lyndale Avenue
Minneapolis, MN 55430
(612) 521-4200

Ms. Jan Terteling
Sales Representative
Certified Traffic Controllers
Route 417
Andover, NY 14806
(607) 478-8469

Mr. James Tisdall
Operations Manager
Colorado Barricade Company, Inc.
2385 S. Lipan
Denver, CO 80223
(303) 922-7815

Mr. Peter Trowhill
Market Manager
3M Canada, Inc.
P.O. Box 5757
Ontario, Canada N6A4T1
(519) 452-6210

Mr. Gerald Ullman
Assistant Research Engineer
TTI
Texas A & M University
College Station, TX 77840
(409) 776-6104

Mr. Joseph Vattilana
Chief Safety Inspector
Delaware Department of Transportation
250 Bear-Christina Road
Bear, DL 19701
(302) 323-4488

Mr. Dan Waddle
Signing and Marking Engineer
Nebraska Department of Roads
P.O. Box 94759
Lincoln, NE 68509
(402) 479-4594

Mr. Raymond G. Welch
City of Greensboro
P.O. Box 3136
Greensboro, NC 27402
(919) 373-2332

Mr. Arnold G. Wheat
Chief Executive Officer
Accident Reconstruction Services
1616 Glenarm Place, Suite 1144
Denver, CO 80202
(303) 595-9045

Mr. Doug Williams
Glare Screen Marketing Manager
Safe-Hit Corporation
2405 IH 35 West
New Braunfels, TX 78130
(512) 629-3161

Mr. Kenneth Wood
Traffic Project Implementation Manager
Illinois Department of Transportation
2300 S. Dirksen Parkway, Room 104
Springfield, IL 62764
(217) 782-3450

Mr. Freddie Vargas
Assistant Traffic Operations Engineer
Florida Department of Transportation
780 S.W., 24th Street
Ft. Lauderdale, FL 33321
(305) 797-8520

Mr. Willie Vidrickson
Sign Man Traffic Control
Saline County Highway Dept.
3424 Airport Road
Salina, KS 67401
(913) 823-2327

Mr. William R. Walsh
I-95 Project Engineer
Florida Department of Transportation
780 SW 24th Street
Ft. Lauderdale, FL 33315
(305) 938-9115

Mr. William H. Wendling
Safety Program Engineer
Federal Highway Administration
P.O. Box 419715
Kansas City, MO 64141
(816) 926-7421

Mr. Joel Wiesenfeld
Consultant
Rutgers University
Building 4161, Kilmer Campus
New Brunswick, NJ 08703
(201) 932-5974

Mr. Greg Wilson
Engineer
Summit County
538 E. South Street
Akron, OH 44311
(216) 379-2850

Mr. Donald L. Woods
Research Engineer
Texas Transportation Institute
CE/TTI Tower, Suite 301
College Station, TX 77843
(409) 845-1717

Mr. Richard Young
Traffic Control & Safety Engineer
Mississippi Highway Department
P.O. Box 1850
Jackson, MS 39215
(601) 944-9333

TOTAL ATTENDEES : 167

APPENDIX C

Supporting Organizations

Several organizations provided assistance in the preparation of the symposium. Their participation is gratefully acknowledged.

The participating organization were:

- American Association of State Highway and Transportation Officials
- American Public Works Association
- American Traffic Safety Service Association, Inc.
- Florida Department of Transportation
- Highway Users Federation for Safety and Mobility
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